NIPIGON RIVER: DEVELOPMENT OF A WATER MANAGEMENT PLAN

OPTIONS REPORT

TECHNICAL REPORT No. 19

April, 1994

RAP

NORTH SHORE
OF LAKE SUPERIOR
REMEDIAL ACTION PLANS

NIPIGON RIVER: DEVELOPMENT OF A WATER MANAGEMENT PLAN

OPTIONS REPORT

Prepared for:

Nipigon River Management Committee

The Study Team:

Atria Engineering Hydraulics Inc.
in association with
Ecological Services for Planning Ltd.
David Evans and MWR & Associates
Alan A. Smith Inc.
E.D. Soulis & K. Ponnambalam

April, 1994

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FORWARD

In response to increased demands being placed on the Nipigon River watershed, the Ministry of Natural Resources, Ontario Hydro, The Nipigon Bay Remedial Action Plan (RAP) Team, the Nipigon RAP Public Advisory Committee and the Ministry of Environment and Energy formed the Nipigon River Management Committee in 1990. Subsequently they were joined by Environment Canada and Fisheries and Oceans Canada.

Habitat restoration is an important goal of the four North Shore of Lake Superior RAPs. The effect water fluctuations and minimum flow rates in the Nipigon River are having on Nipigon Bay are specific concerns identified by the Nipigon Bay RAP Public Advisory Committee. Nipigon Bay is one of 43 areas of concern around the Great Lakes for which water remedial action plans are being developed to address specific environmental problems and impaired beneficial uses.

Therefore, the goal of this project is to establish, through public involvement, a management option that will reduce the impacts Ontario Hydro's hydroelectric dams on the Nipigon River are having on the Lake Nipigon/Nipigon River watershed, particularly the Nipigon River fishery.

This project is jointly funded by the federal Government's Great Lakes Cleanup Fund and each of the agencies on the Nipigon River Management Committee. It is one of eight habitat restoration projects that have been initiated since 1990 to restore self-sustaining fish stocks in Nipigon Bay.

The Great Lakes Cleanup Fund provides funds to help develop and demonstrate technologies and remedial programs to meet federal responsibilities in Canadian areas of concern throughout the Great Lakes Basin.

ERRATA

1) FORWARD, para. 1, line 2 - should read "...the Nipigon Bay RAP Public Advisory Committee..."

2) page iv, Table - in Comments column, the term "...value..." should read "...average annual value..." at all three locations

3) SUMMARY, page v, point 6 - should read "...varies from \$26.93 million to \$30.86 million..."

4) ACKNOWLEDGEMENTS - should read "Gord Laird, Area Supervisor, Lake Nipigon West Area..."

5) page 1, Section 1.1, para. 1, line 5 - should read "...the Nipigon Bay Remedial Action Plan..."

6) page 37, Section 3.5.2, para. 4, line 5 - should read "...seen in Figure 3.11. Figure 3.11 includes, but does not identify, the effects of Lake Superior water levels. The level of Lake Helen is influenced by the level of Lake Superior (see Appendix 2B.2 of the *Draft Options Report*). The model can now be..."

7) page 58, Table 4.2 - in Comments column, the term "...value..." should read "...average annual value..." at all three locations

8) page 65, point 2 - should read "...varies from \$26.93 million to \$30.86 million..."

9) Appendix E - the following should be added to the end of Appendix E

"In this study, the cost $c^t(s^{t-1}, s^t)$ is determined from weighted penalty costs as described in Chapter 3, Section 2 of this report. This cost depends on the Lake Nipigon storage level and the release from the lake and is a function of the week number.

"<u>References:</u>

Ponnambalam, K. 1987. Optimization of the Integrated Operation of Multi-reservoir Irrigation Systems. Ph.D. Dissertation, University of Toronto.

A SUMMARY OF THE OPTIONS REPORT

GOAL OF STUDY

The goal of this study is to establish, through public involvement, a management option that will reduce the impacts of the operation of Ontario Hydro's Nipigon River hydroelectric dams on the Lake Nipigon/Nipigon River watershed, particularly on the Nipigon River fishery. This management option for the Nipigon River must not further aggravate the impacts of fluctuating water levels on Lake Nipigon. This study commenced in July, 1992 and is to be completed by June, 1994.

STEPS IN THE STUDY

In the first year of the study, stakeholders in the Nipigon River, Lake Helen and Lake Nipigon region were interviewed by the Study Team. As well, data was collected from available information sources. A *Draft Options Report* was released in May 1993 and represented the findings of the first year. It outlined the users and conflicts, stakeholders' concerns and a preliminary set of management options with supporting data. All those interviewed, as well as other interested parties, received a copy of the report so that they could comment on the findings.

The release of the first report was followed by a series of public meetings which were held in Nipigon, Thunder Bay and Beardmore in June 1993.

In the second year of the project, costed options were prepared and evaluated by the Study Team with the assistance of the community-based Nipigon River Water Quantity Management Working Group and other stakeholders. This *Options Report* presents the costed options.

Following this report there will be a period for public comment. After the public comment period, a preferred water quantity management option will be determined by the Study Team in consultation with the Working Group. A *Final Report* detailing the preferred option and other recommendations will be submitted to the Nipigon River Management Committee. The results will be released to the community.

THIS REPORT

This report presents a set of "costed" management options. Costs are expressed in terms of the relative changes in the lake levels and river flows that would most likely be experienced by the stakeholders due to each of the options.

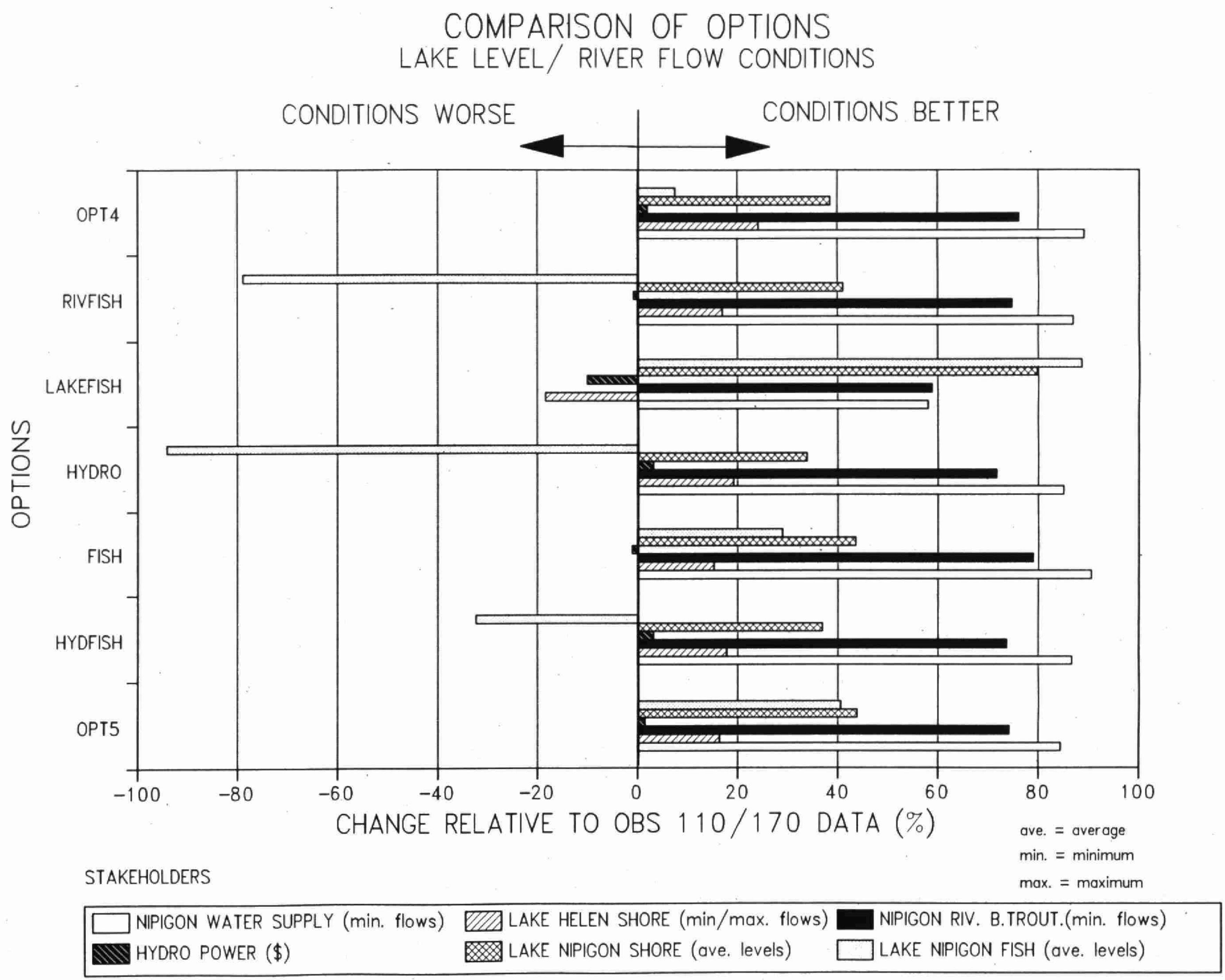
The options were developed through the use of a multi-objective optimization computer model. The model considers what levels and flows the stakeholders want at various times of the year. Options are based on weighting factors which outline the importance of the stakeholders relative to each other. The Study Team was assisted by the Working Group in considering different scenarios to be modelled as options.

THE OPTIONS

The options that were optimized and simulated are summarized in the following Table:

Option	Description	Weighting Factors
OBS 110	**OBS**erved data (1951-1986) with minimum flow of **110** m^3/s from October to May and 170 m^3/s from June to September.	not applicable
RIVFISH	Nipigon **RIV**er **FISH** (brook trout) most important consideration. Try to maintain River flows between 350 m^3/s & 400 m^3/s in October & November and above 270 m^3/s from December to September.	•100% Nipigon River brook trout.
LAKEFISH	**LAKE** Nipigon **FISH** most important consideration. More closely mimic natural Lake Nipigon average fluctuations by trying to get levels between 259.85 m & 259.8 m (852.6′ & 852.4′) during October & November, between 259.8 m & 259.49 m (852.4′ & 851.4′) from December to May and between 259.49 m & 260.0 m (851.4′ & 853′) from June to September.	•100% Lake Nipigon fish.
HYDRO	**HYDRO**-electric power generation most important consideration. Try to maintain maximum daily River flow at 390 m^3/s throughout the year.	•100% hydro power generation.
FISH	Equal consideration given to **FISH** from Lake and River (brook trout).	•50% Lake Nipigon fish •50% Nipigon River brook trout.
HYDFISH	Equal consideration given to **HYD**ro and Lake and River **FISH**.	•33⅓% Lake Nipigon fish •33⅓% Nipigon River brook trout •33⅓% hydro power generation.
OPT4	**OPT**ion combining the interests of various stakeholders with equal consideration to River and Lake interests and with a high importance placed on fish on both the River and the Lake.	•45% Lake Nipigon fish •35% Nipigon River brook trout •10% hydro power generation •5% each to Lake Nipigon and Lake Helen shore owners/users
OPT5	**OPT**ion combining the interests of various stakeholders, similar to OPT4 but with greater emphasis on Lake fish.	•60% Lake Nipigon fish •25% Nipigon River brook trout •10% hydro power generation •2.5% each to Lake Nipigon and Lake Helen shore owners/users

Note: All the options, unless otherwise specified, are based on maintaining a minimum flow, when possible, in the Nipigon River of 270 m^3/s from October to May and 170 m^3/s from June to September.


COMPARISON OF OPTIONS
LAKE LEVEL/ RIVER FLOW CONDITIONS
CONDITIONS WORSE
CONDITIONS BETTER
OPTIONS
OPT4
RIVFISH
LAKEFISH
HYDRO
FISH
HYDFISH
OPT5
−100
−80
−60
−40
−20
0
20
40
60
80
100
CHANGE RELATIVE TO OBS 110/170 DATA (%)
ave. = average
min. = minimum
max. = maximum
STAKEHOLDERS
NIPIGON WATER SUPPLY (min. flows)
HYDRO POWER ($)
LAKE HELEN SHORE (min/max. flows)
LAKE NIPIGON SHORE (ave. levels)
NIPIGON RIV. B.TROUT.(min. flows)
LAKE NIPIGON FISH (ave. levels)

The Figure on the preceeding page provides a comparison of the simulated options. For each option, it shows whether the potential levels of Lake Nipigon or the flows in the Nipigon River would be better or worse, for the various stakeholders, than the historic levels or flows from 1951 to 1986. The Figure indicates the estimated degree of change to the existing system that would accompany each option. The comparison is based on the penalty values and the estimated value of the hydro-electric power. A comparison of the average annual value of the hydro-electric power simulated by the computer model is provided in the table that follows.

Simulated Average Annual Value of Hydro-Electric Power

Option	Average Annual Value of Hydro Power ($)	Difference in Average Annual Value from OBS 110 ($)	Comments
OBS 110	29,873,839	n/a	Additional restriction on winter minimum flow (from 110 m^3/s to 270 m^3/s) while maintaining the same Lake Nipigon water levels reduces value of power by $346,522.
RIVFISH	29,686,810	-187,029	
LAKEFISH	26,927,553	-2,946,286	
HYDRO	30,855,177	+981,338	Allowing minimum flow down to 70 m^3/s year-round, while maintaining average flow determined by HYDRO option, would provide an additional value of $182,000.
FISH	29,544,004	-329,835	
HYDFISH	30,822,970	+949,131	
OPT4	30,520,669	+646,830	
OPT5	30,365,374	+491,535	Allowing minimum flow down to 70 m^3/s year-round, while maintaining average flow determined by OPT5 option, would provide an additional value of $361,000.

INITIAL COMPARISON OF OPTIONS

The optimization and simulation of the options are not exact predictions of what will happen. However, they provide a good indication of the relative impacts of the options based on the best available data. The following key points are evident from an initial comparison of the results:

- Increasing the minimum flow restriction from 110 m^3/s to 270 m^3/s, during the months of October to May, significantly improves flow conditions for stakeholders on the river, especially the brook trout.

- With a minimum flow restriction of 270 m^3/s from October to May, higher weighting factors are necessary for Lake Nipigon stakeholders, relative to the river stakeholders, in order to keep Lake Nipigon water levels as close as possible to the desired conditions for lake fish.

- Decreasing the October to May minimum flow restriction may improve the Lake Nipigon water level conditions for fish on the lake but not without a significant accompanying decrease in the suitablility of the Nipigon River flow conditions for the river brook trout.

- Options with weighting factors ranging from 100 percent to 25 percent for the Nipigon River brook trout (i.e., RIVFISH, FISH, HYDFISH, OPT4 and OPT5), along with an October to May minimum flow restriction of 270 m^3/s, result in relatively similar improvements (varying from 72 to 79 percent, see Figure) in the minimum flow conditions for the river brook trout.

- Comparison of the options (see Figure) suggests that Options RIVFISH, LAKEFISH, HYDRO and HYDFISH may be the least desirable. RIVFISH, HYDRO and HYDFISH result in significantly worse water level conditions for Lake Nipigon fish. RIVFISH also reduces the value of the power slightly. Option LAKEFISH makes the flow conditions worse for Lake Helen/Nipigon River shore owners and users and boaters and also reduces the value of the power.

  The remaining options, FISH, OPT4 and OPT5, perform in a similar manner for the all the stakeholders, except option OPT5 which is significantly better than FISH for Lake Nipigon fish. Option FISH is better for Lake Nipigon fish than OPT4. FISH also results in a relatively small decrease in the value of the hydro-electric power.

- The average annual value of the power generated by the options varies from $29.54 million to $30.86 million. The options do not affect the production at downstream stations (i.e., Niagara and St. Lawrence).

- Permitting Hydro to drop the minimum river flow to 70 m^3/s (on an hourly basis during the off-peak demand period, midnight to 7:00 a.m.) would increase the average annual value of the power for Options HYDRO and OPT5 by $182,000 (0.6 percent) and $361,000 (1.2 percent) respectively. The increased value of power would be accompanied by a significant decrease in the suitability of the flow conditions for the river brook trout (3 to 4 times less suitable) as well as for other river stakeholders.

- The options provide conditions which are, on average, better or worse than desired by the various stakeholders. There will still be times when the lake levels or river flows will be higher or lower than desired due to the large role played by the natural inflow conditions.

NEXT STEPS

Following the release of this *Options Report*, the Study Team will be soliciting comments and opinions from the stakeholders regarding the presented options and the expected advantages and disadvantages of each option. The community-based Working Group will assist the Study Team in reviewing and evaluating the merits of the options. Other stakeholders will also be reviewing the options to assess how the options perform with respect to their interests.

The objective of this next phase of the study is to develop a preferred water quantity management option. The Study Team will work towards building a consensus amongst the stakeholders on a preferred option. The final report of the Study Team to the Nipigon River Management Committee is scheduled for completion by the end of June, 1994.

THE CONSULTATION PROGRAM

An informal open house was held January 12, 1994, at the Nipigon Legion Hall prior to the Working Group meeting. The Study Team met with representatives of several First Nations on January 13, 1994. On-going discussions have been maintained with Ministry of Natural Resources and Ontario Hydro staff.

All those on the Study Team's mailing list, including all those interviewed during the first year, as well as other interested parties, will receive a summarized version of this report so that they may comment on the findings. A complete copy of the *Options Report* will be sent to anyone who requests one.

The Study Team is interested in your views and comments. We have posed a number of consultation questions at the end of this summary. Your response would be most helpful.

The Nipigon River Water Quantity Management Working Group

The Study Team has been consulting with the community-based Nipigon River Water Quantity Management Working Group. The Working Group met on June 24, September 8, October 2, November 3, 1993 and January 12, February 2, and March 2, 1994. The remaining meeting is scheduled for June, 1994 in Nipigon, at which time they will discuss the outcome of the public consultation. It is anticipated that the Working Group will be in a position to decide on a preferred option for recommendation to the Study Team. A further announcement outlining the exact date, time and place will be made. The meetings are open and everyone is welcome to attend.

CONSULTATION QUESTIONS

In addition to any comments you may have on the *Options Report*, answers to the following questions would be most helpful:

1) Which option best serves the interests of all the affected stakeholders?

2) Which option achieves the purpose of the project the best?

3) Are there other approaches to achieving the goal of reducing the impacts of fluctuating water levels besides developing a new strategy for operation of Ontario Hydro' generating stations?

In order to better assist us in evaluating the community response, your comments should be received by **May 31, 1994**.

Written comments can either be provided to the Study Team at the Working Group meetings or mailed to:

Atria Engineering Hydraulics Inc.
8 Stavebank Road North, Suite 401
Mississauga, Ontario
L5G 2T4

Attention: Mark Kolberg, P.Eng.

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April, 1994

ACKNOWLEDGEMENTS

Nipigon River Management Committee

Ken Cullis, Coordinator, Lake Superior Environmental Programs (chairman of committee)
Jake Vander Wal, Manager, Federal/Provincial Environmental Programs for Lake Superior
Dave Nuttall, Public Advisory Committee, Nipigon Bay Remedial Action Plan (RAP)
Mike Boutilier, Ontario Hydro
Gord Laird, Area Supervisor, Nipigon East Area, Ontario Ministry of Natural Resources
Rob Swainson, Ontario Ministry of Natural Resources, Nipigon District
Serge Metikosh, Fish Habitat Management, Fisheries and Oceans Canada

Former Members
Bryan Lomenda, Ontario Hydro
Dave Hollinger, Ontario Ministry of Environment and Energy
Rod Bosch, Ontario Hydro
Bill Hutson, Ontario Ministry of Natural Resources, Nipigon

Working Group

In attendance at one or more meetings:

Art Joseph
Adam Taff
Ken Larocque
Gwen Nyman
Dan Taisey
Bud Lindeman
Bill Heitanen
Dave Crawford
Arlene Wawia
Terry Bouchard
Pat McGuire
Dennis Cassidy
Phil Douglas
Dave Nuttall
Barbara Cassidy
Ray Dupuis

Note: Other stakeholders were invited to participate.

Thanks to all who took the time to provide information and comments.

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1.0 <u>INTRODUCTION</u>

1.1 BACKGROUND

This report is the second in a series of reports which document the development of a water management plan for the Nipigon River system. This project was initiated by the Nipigon River Management Committee, which includes representatives from the Ontario Ministries of Natural Resources and Environment and Energy, Ontario Hydro, the Nipigon Bay Remedial Action Plan team, the Nipigon Remedial Action Plan Public Advisory Committee, Environment Canada and Fisheries and Oceans Canada.

This two-year study is being conducted by the Study Team headed by Atria Engineering Hydraulics Inc. (Atria). Atria has been assisted by David Evans, community affairs consultant, Ecological Services for Planning Limited (ESP), Alan A. Smith Inc. (AAS), E. Soulis, K. Ponnambalam, and MWR and Associates.

The first report, *Nipigon River - Development of a Water Management Plan, Draft Options Report* (Atria, 1993), was released to the public in May, 1993. It marked the half-way point in the study. The report summarized issues identified by individuals and groups, interviewed by members of the Study Team, who had concerns about the effects of water level fluctuations on the Nipigon system.

The *Draft Options Report* also identified some conceptual management options to address stakeholder concerns and solicited public input to each of them. The report was discussed at public meetings held in Nipigon, Thunder Bay and Beardmore in June 1993. Seventy members of the community attended these meetings.

Following the public meetings, a multi-stakeholder, community-based Working Group was established to assist the Study Team in developing a preferred option for managing water quantities in the Lake Nipigon/Nipigon River system. The Working Group is discussed further in Section 2.3.

1.2 SCOPE OF STUDY

The overall goal of the study was outlined in the Summary of the *Draft Options Report* as follows:

> "The goal of this study is to establish, through public involvement, a management option that will reduce the impacts of the operation of Ontario Hydro's Nipigon River hydroelectric dams on the Lake Nipigon/Nipigon River watershed, particularly on the Nipigon River fishery. This management option for the Nipigon River must not further aggravate the impacts of fluctuating water levels on Lake Nipigon."

It is the Study Team's understanding that the stakeholders hope to use the results of this study and public consultation exercise to reach a long-term agreement for the management of the water quantity in the Nipigon system.

It was recognized in the *Draft Options Report* that other factors, other than fluctuating water levels, influence the health of the fisheries in the Nipigon River and Lake Nipigon. However, as outlined in the stated goal and in the study Terms of Reference, this study is limited to the development of a water quantity management plan for levels and flows in the Lake Nipigon/Nipigon River system.

Readers are directed to the *Draft Options Report* for details of the study approach and process.

1.3 THIS REPORT

This report outlines the continuing public consultation process including the community-based Working Group. The report describes how the interests of the various stakeholders have been taken into consideration through the use of penalty functions and weighting factors. A range of options for managing the water quantity in the Nipigon system is presented. The multi-objective optimization computer model which was used to develop the options is described. The results of the simulation of the performance of the options are provided. Comparisons of the results with historically observed data are presented.

1.4 NEXT STEPS

Following the release of this *Options Report,* the Study Team will be soliciting comments and opinions from the stakeholders regarding the presented options and the expected advantages and disadvantages of each option. The community-based Working Group will continue to assist the Study Team in reviewing and evaluating the merits of the options. Other stakeholders will also be reviewing the options to assess how the options perform with respect to their interests.

The objective of this next phase of the study is to develop a preferred water quantity management option. The Study Team will work towards building a consensus amongst the stakeholders on a preferred option. The final report of the Study Team to the Nipigon River Management Committee is scheduled for completion by the end of June, 1994.

2.0 PUBLIC CONSULTATION

2.1 EARLIER PUBLIC CONSULTATION FINDINGS

The *Draft Options Report* outlined the public consultation effort that had been undertaken up to the end of the first year of the study including interviews, mailings of "Update" newsletters, an article in the Nipigon Bay RAP and advertising for public meetings.

In order to present the *Draft Options Report* to the public, a series of meetings were held in June, 1993. Appendix A provides a summary of the June public meetings and documentation of feedback received from the people.

Following the June public meetings, the Study Team concluded that they had successfully identified all the users, their various interests and the conflicts between the interests. People did express opinions that the *Draft Options Report* placed too much emphasis on certain users or issues and not enough emphasis on some of the other issues. This divergence was often based on some differences in the users' interests on Lake Nipigon and the lower Nipigon River. Nevertheless, there appears to be a strong consensus that fish habitat and spawning and the overall environment are the most important considerations. Also, remarks were consistently made that the preferred solution would be a compromise. Generally people expressed an appreciation of other people's interests. They were hopeful that finally, all the interests were going to be considered fairly.

2.2 FURTHER CONSULTATION ACTIVITIES

During the second year of the study, the public consultation effort is being continued. A big part of the public consultation effort is now being carried out through the Nipigon River Water Quantity Management Working Group. The Working Group is discussed in Section 2.3.

The third in a series of *Update* newsletters was sent out in November 1993. Media contacts are outlined in Section 2.3.

An informal open house was held in Nipigon on January 12, 1994, at the Legion Hall (from 5:30 to 7:30 pm) for people to drop in and ask questions and provide comments. The Study Team met with representatives of several First Nations on January 13, 1994. A followup meeting was held March 3, 1994. On-going discussions have been maintained with Ministry of Natural Resources and Ontario Hydro staff.

A preliminary version of this report (dated December, 1993) was provided to the Nipigon River Management Committee, the Working Group and other stakeholders in January, 1994. As a result of comments and concerns raised and based on a further review of the computer model, the Study Team determined that more work was required on the report. This was explained in the January 27, 1994, *Update* newsletter (see Appendix C) which was sent to everyone on the mailing list.

All those on the Study Team's mailing list, including all those interviewed during the first year, as well as other interested parties, will receive a summarized version of this report so that they may comment on the findings. The Study Team is soliciting the comments and opinions of the stakeholders. A list of consultation questions has been provided in the summarized version and in the Summary of this report. A complete copy of this *Options Report* will be sent to anyone who requests one.

Following this report there will be a period for public comment. After the public comment period, a preferred water quantity management option will be determined by the Study Team in consultation with the Working Group. A final report detailing the preferred option will be submitted to the Nipigon River Management Committee by the end of June, 1994. The results will be released to the community. A public information session is planned for Nipigon. People will be notified of this session.

2.3 WATER QUANTITY MANAGEMENT WORKING GROUP

The community-based Water Quantity Management Working Group was established to assist the Study Team in developing a preferred option for managing the water quantities in the Lake Nipigon/Nipigon River system. The final Terms of Reference for the Working Group is presented in Appendix B. Invited membership to the Working Group includes a broad spectrum of community members representing shoreline owners, tourism, recreation, boaters, municipal works, the general public, environmental protection, First Nations, anglers and hunters and commercial fishing interests. Also, membership includes participants from Lake Nipigon, Polly Lake, Lake Helen and along the Nipigon River. The Working Group is working to arrive at a consensus on the best management option.

The Working Group does not include representation from Ontario Hydro and the Ministry of Natural Resources. The views of these two significant stakeholders are channelled through the Nipigon River Management Committee. Representatives from Ontario Hydro and the Ministry of Natural Resources have attended meetings of the Working Group at the request of the members.

A summary of earlier progress by the Working Group was provided in the November 1993 issue of the *UPDATE* newsletter put out by the Study Team. This information is repeated here along with an outline of subsequent progress:

- to date seven meetings have been held: June 24, September 8, October 2 and November 3, 1993 and January 12, February 2 and March 2, 1994;

- the Working Group meetings were also attended by various observers and technical resource people including representatives from Ontario Hydro and the Nipigon office of the Ministry of Natural Resources;

- comment sheets and written correspondence received by the Study Team concerning the *Draft Options Report* were discussed;

- meetings of the Working Group have been open to the public and the media (Appendix C contains a typical copy of a notice sent to media outlets) - the project manager was interviewed by the local media (including CJLB and CBQ radio (on-air, October 6, 1993), Nipigon-Red Rock Gazette newspaper, and Thunder Bay TV News; a news release was issued to all the print, television and radio outlets in the vicinity of the study area in October (see Appendix C); articles appeared in the Nipigon-Red Rock Gazette and in the Lake Nipigon Watch Dog Society newsletter (Volume 2, Number 2, Summer 1993 - see Appendix C);

- the Working Group has assisted the Study Team in developing input for the computer modelling program that optimizes and simulates various flow rates and levels and evaluates them against the concerns expressed by the stakeholders;

- a workshop was held for the Working Group and the Nipigon River Management Committee to explain the computer model and to review the penalty functions and to assist in determining the weights for each concern (i.e., fish habitat, hydro-electric requirements, shoreline owners and users, boaters, water intakes) as input into the model; and

- the Working Group and the Nipigon River Management Committee both reviewed preliminary results from the computer model and looked at the effects of various changes (i.e., if a certain river flow is set, does it make it worse or better for Lake Nipigon shoreline owners).

- the Study Team presented revised penalty functions and results to the Working Group following the circulation of the preliminary version of the *Options Report*.

The last Working Group meeting is scheduled for June, 1994, in Nipigon, at which time they will discuss the outcome of the public consultation. It is anticipated that the Working Group will be in a position to decide on a preferred option for recommendation to the Study Team. A further announcement outlining the exact date, time and place of the meeting will be made. The meetings are open and everyone is welcome to attend.

3.0 DEVELOPING THE OPTIONS

3.1 GENERAL DESCRIPTION OF MODELLING PROCEDURE

The preferred option for managing the water levels of Lake Nipigon and the flows in the Nipigon River is being developed through a process which uses a multi-objective optimization computer model. The computer model provides a way to quantify the competing interests so that an optimal or preferred operating option, which represents a reasonable compromise to all the stakeholders, can be identified.

The steps in developing the options to be modelled and evaluated can be summarized as follows:

Step	General Description		Modelling Action
1)	Input what the stakeholders want	⇒	Prepare stakeholder **penalty functions**
2)	Establish relative importance of the various stakeholders	⇒	Assign **weighting factors** to stakeholder penalty functions
3)	Prepare option	⇒	Combine penalty functions based on specified weighting factors to generate an **option**.
4)	Given the option criteria, determine the best strategy for releasing water from Lake Nipigon to the Nipigon River	⇒	Optimal strategy determined by using computer **optimization** model
5)	Compare option with observed data from 1951 to 1986	⇒	Lake Nipigon levels and Nipigon River flows simulated using computer **simulation** model

Penalty functions are described in Section 3.2 with the specific Nipigon stakeholder penalty functions presented in Sections 3.2.2 through 3.2.9.

Weighting factors are discussed in Section 3.3.

The options are presented in Section 3.4.

The optimization and simulation procedures are outlined in Sections 3.5 and 3.6 respectively.

The results of the simulated options are presented in Section 4.0.

3.2 PENALTY FUNCTIONS

3.2.1 Introduction

The first step in the process of finding the best option was to develop a penalty function for each of the Nipigon stakeholders.

General Description of Penalty Functions

Penalty functions are used to represent the water levels or river flows that each stakeholder wants during different times of the year. Included in the penalty functions are the "desired" or "target" levels and/or flows for that particular stakeholder. This indicates the range of water levels or flows for which no cost or penalty is experienced by the stakeholder (i.e., the "desired" or "target" level/flow). Also included in each penalty function is a measure of the "cost" to the different stakeholders if the actual water level or flow is greater than or less than the level/flow that they wanted. The penalty function also indicates how quickly the expected cost or penalty increases as the water level or flow rises above or falls below the desired value(s).

The penalty "cost" is not expressed in dollars because the "costs" are noncommensurable. That is to say the costs can not be measured by the same standard (i.e., dollars). The penalties are merely meant to be representative of a negative impact or an inconvenience. They are not exact, precise values.

The penalty functions are representative of the average conditions that are desired by each of the stakeholders. It should be pointed out that there will still be variations in the river flows and lake levels. There will still be times of high water and times of low water which are the result of wet or dry years.

A penalty function can be considered like a speeding ticket. The "ideal" or "target" value is the speed limit. The penalty or cost that you incur by going above the speed limit (that is if you get caught!) depends on how fast you were going; the faster you go, the greater the fine. Also, you can suffer a penalty (i.e., get a ticket) for going too slow.

More discussion of penalty functions, including how they are combined and how they are incorporated into the multi-objective optimization model, was provided in Appendix 6A of the *Draft Options Report* (Atria, 1993).

Nipigon Stakeholder Penalty Functions

Through interviews with stakeholders and discussions with the Working Group, the Study Team found that generally stakeholder positions fell into one or more of seven categories:

1) those concerned with brook trout and other fish on the lower Nipigon River;

2) those concerned with fish species in Lake Nipigon - namely whitefish, walleye, lake trout and brook trout;

3) those concerned with maximizing the production of hydro-electric power;

4) shoreline property owners and users of Lake Helen and Polly Lake, and shoreline property owners along the River;

5) shoreline property owners and users on Lake Nipigon;

6) boaters on Lake Nipigon and Lake Helen; and

7) Town of Nipigon and Red Rock Indian Band water supply.

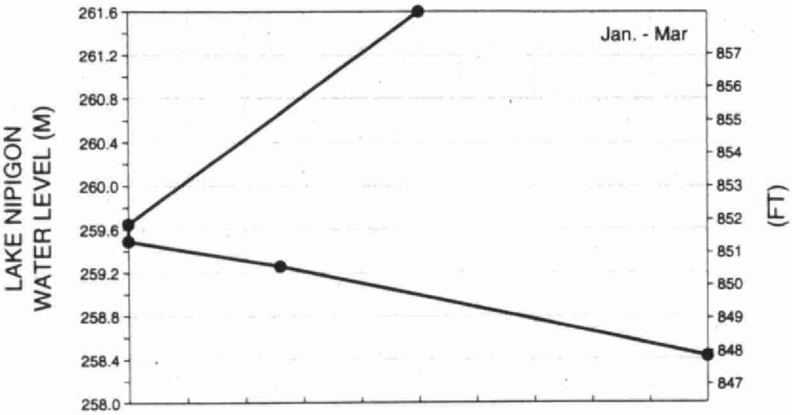
Penalty functions were prepared for each of these stakeholders. The functions are presented in Sections 3.2.2 to 3.2.9.

The Nipigon stakeholder penalty functions presented in this report are reasonable representations of the interests of the various stakeholders. The functions are based on the best available data gathered by the Study Team through their investigations, during interviews with the stakeholders and at public meetings. The *Draft Options Report* (Atria, 1993) contains much of this information.

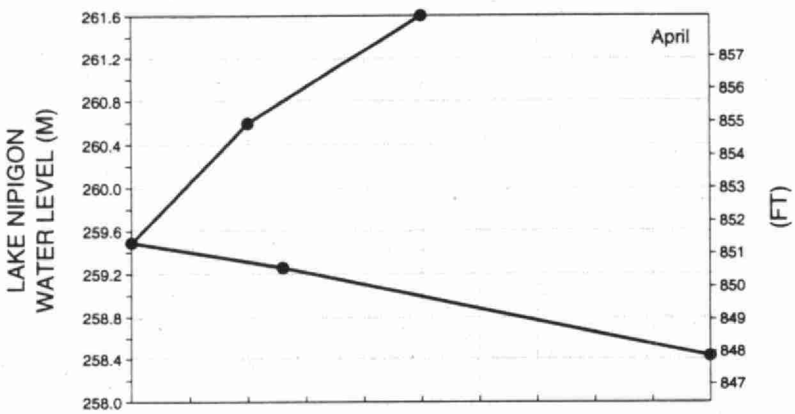
An initial set of penalty functions was presented to a joint Working Group/Management Committee workshop that was held in Nipigon on October 2, 1993. The Study Team subsequently revised the penalty functions, where appropriate, based on comments made at the workshop and on additional input that was received from Ontario Hydro technical and environmental staff, MNR fisheries staff and other major stakeholders. The penalty functions can be updated as more or improved data becomes available.

The penalty functions are in the form of a series of graphs which have the Lake Nipigon water level (in metres, on the right hand side and feet on the left hand side) or Nipigon River discharge (in m^3/s) up the vertical axis and the penalty, ranging from "0.0" (desired) to "1.0" (unacceptable), along the horizontal or bottom axis. The bold line represents the relationship between the level or flow and the penalty. The water level or discharge at the "0.0 penalty" position represents the most desired value for that particular stakeholder. As you go higher or lower than the target level or flow, the penalty generally increases. Different penalty functions are given for different periods of the year as appropriate. For each stakeholder, the modelling procedure is capable of handling a different penalty function for each of the 52 weeks in a year. Figure 3.1 provides an example of a penalty function.

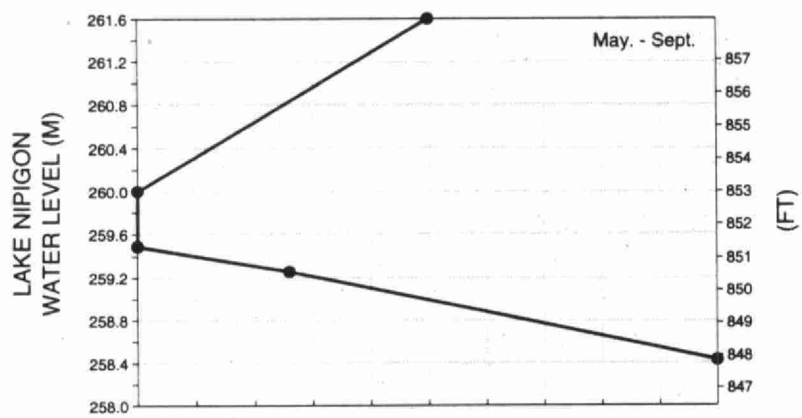
Figure 3.1 PENALTY FUNCTIONS FOR
LAKE NIPIGON
FISH



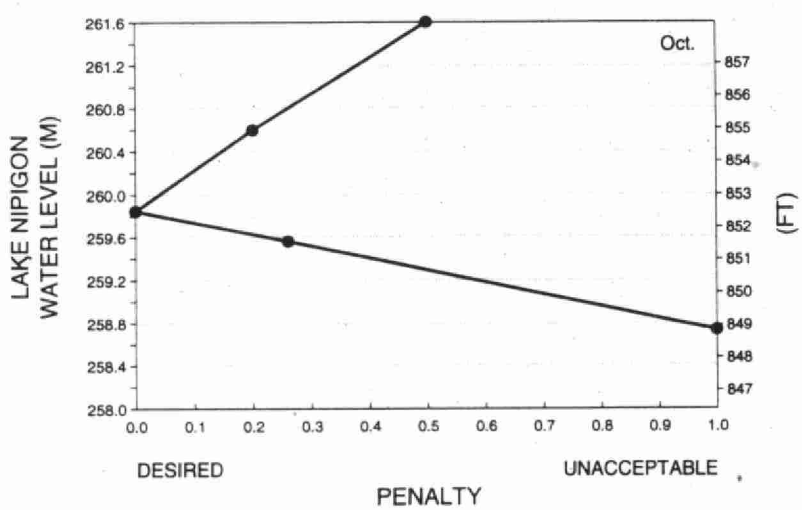
WATER LEVEL (M)	(FT)	PENALTY
258.43	847.8	1.00
259.26	850.6	0.26
259.49	851.3	0.00
259.65	851.8	0.00
261.60	858.2	0.50
262.60	861.5	1.00



WATER LEVEL (M)	(FT)	PENALTY
258.43	847.8	1.00
259.26	850.6	0.26
259.49	851.3	0.00
260.60	855.0	0.20
261.60	858.2	0.50
262.60	861.5	1.00

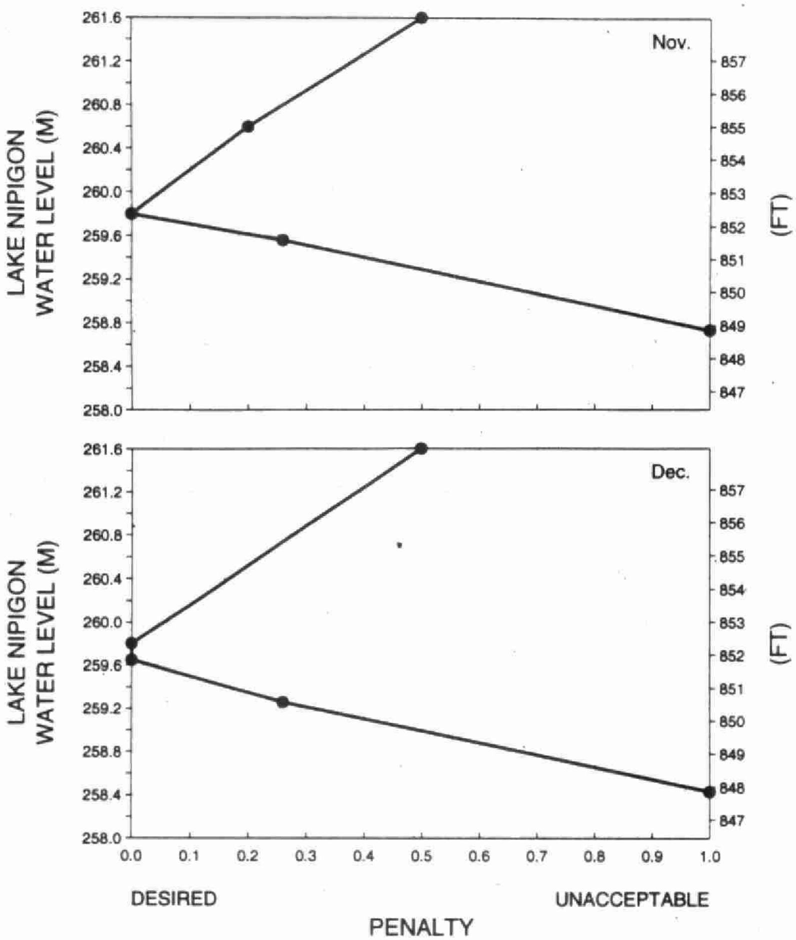


WATER LEVEL (M)	(FT)	PENALTY
258.43	847.8	1.00
259.26	850.6	0.26
259.49	851.3	0.00
260.00	853.0	0.00
261.60	858.2	0.50
262.60	861.5	1.00



WATER LEVEL (M)	(FT)	PENALTY
258.73	848.8	1.00
259.56	851.6	0.26
259.85	852.5	0.00
260.60	855.0	0.20
261.60	858.2	0.50
262.60	861.5	1.00

Figure 3.1 (cont'd) PENALTY FUNCTIONS FOR
LAKE NIPIGON
FISH



WATER LEVEL (M)	(FT)	PENALTY
258.73	848.8	1.00
259.56	851.6	0.26
259.80	852.3	0.00
260.60	855.0	0.20
261.60	858.2	0.50
262.60	861.5	1.00

WATER LEVEL (M)	(FT)	PENALTY
258.43	847.8	1.00
259.26	850.6	0.26
259.65	851.8	0.00
259.80	852.3	0.00
261.60	858.2	0.50
262.60	861.5	1.00

3.2.2 Lake Nipigon Fish

Summary

Fish in Lake Nipigon require appropriate water level conditions for spawning, incubation and hatching. The penalty functions for Lake Nipigon fish, shown in Figure 3.1, are representative of the magnitude and timing of the estimated natural fluctuations of the lake (above and below an overall average level that is higher than the natural average level, prior to the construction of the dams). Natural fluctuations (in magnitude and timing) would be beneficial for all native species.

The target level during the fall spawning in October and November is between 259.85 m to 259.80 m (852.6′ to 852.4′). From December to May, the target level is between 259.80 m to 259.49 m (852.4′ to 851.4′). From May to September, the target is that water levels be above 259.49 m (851.4′) and below 260.0 (853.0′).

Discussion

The fishery on Lake Nipigon is very valuable as a commercial, subsistence and angling resource. These aspects were discussed in the *Draft Options Report* (Atria, 1993). The interests of other users are linked with the Lake Nipigon fisheries. Wildlife that depend on the fish in lake, shoreline flora and fauna, commercial fisherman, First Nation subsistence fishermen, anglers (both local and tourist alike), and local tourist businesses (charter operators, restaurants, motels, suppliers) will clearly benefit if the Lake Nipigon fishery is healthy. A healthy fishery dominated by native species is one indicator of a healthy environment.

It is not the purpose of this study to attempt to characterize the present health of the Lake Nipigon fishery as either good or bad. However, the Study Team does require a means for assessing whether changes to the water levels of Lake Nipigon, due to the simulated options, can be considered as generally better for the fishery or worse for the fishery. This is necessary to determine if the goal of the study, as described in Section 1.2, has been achieved. The penalty functions for the Lake Nipigon fishery provide the means for assessing if the options improve or aggravate the impacts of fluctuating water levels on fish on Lake Nipigon. The penalty functions used (see Figure 3.1) attempt to have the lake levels more closely mimic the natural fluctuations of the lake in magnitude and timing.

Water levels on Lake Nipigon can be considered as consisting of two components: 1) the pattern of seasonal fluctuations (i.e., high in early summer, dropping through the fall to low in late spring just prior to freshet); and 2) the long-term average around which the seasonal fluctuation varies (as seen in Figure 4.4.2, *Draft Options Report*, May 1993, page 75).

The long-term average or mean water level is higher than it would have been under natural conditions (i.e., before the dams were built and before the Ogoki diversion). For example, the observed average water level from 1950 to 1989 (after Pine Portage GS and Ogoki diversion) is 0.62 m (2.02′) higher than the estimated natural average (i.e., without the dams and the diversion). The

natural conditions were estimated by Ontario Hydro using a computer simulation (see Section 4.4 and Appendix 4A.1 of *Draft Options Report,* May 1993).

The seasonal variation depends on the inflow to the watershed and the manipulation of the outflow by Ontario Hydro. By superimposing the estimated natural average monthly water level variation on the observed data (using the mean levels as a common reference point), one can more readily compare the differences as follows:

Time of Year	Difference
- August	- observed and natural levels virtually the same
- Fall	- observed level higher than natural level
- April	- natural level at its lowest point of the year but this is higher than the observed level
- May	- natural level beginning to increase but observed level remains low

The proposed penalty function is based on trying to have seasonal fluctuations that more closely resemble the natural conditions but around the present average level. Essentially this means trying to keep water levels slightly lower in the fall through to the late winter and slightly higher in the spring if possible. This would result in less drawdown from the fall (October and November) level to the spring low.

There would still be variation in the fluctuations from year-to-year (i.e., the levels would not be the same every year) due to the strong influence of mother nature. Some variability in the seasonal fluctuations is desirable for the shoreline ecosystem.

Brook trout spawn in shallow depths along the shoreline (±0.2 m to 2.0 m). The spawning period is approximately from October to November and the emergence period from mid-April to May. Yearly variations of between one to two weeks can occur. Brook trout require specific groundwater upwelling conditions for spawning locations. Two brook trout spawning locations, South Bay and West Bay, are documented in the literature (see Ritchie and Black 1988, as cited in Atria 1993). Other spawning locations around the lake and in feeder streams are reported by local residents, anglers and commercial fishermen. Elevations of individual redds at South Bay and West Bay were measured by MNR in 1990 (R. Swainson, MNR, pers. comm. 1993). The range of redd elevations reported by the MNR staff was consistent with the range given by Ritchie and Black 1988). In April 1993, the Study Team measured the elevation of several redds at South Bay. Based on the these various sources of information, the elevations of the 23 identified and measured brook trout redds at South and West Bays are summarized as follows:

Measured Redds at South and West Bays	Elevation
maximum measured redd elevation	259.83 m (852.5′)
20 of 23 measured redds lower than	259.46 m (851.3′)
18 of 23 measured redds lower than	259.26 m (850.6′)
12 of 23 measured redds lower than	258.94 m (849.6′)
6 of 23 measured redds lower than	258.85 m (849.3′)
minimum measured redd elevation	258.43 m (847.9′).

Elevations of other redds around the lake have not as yet been measured and documented.

At spawning, the redds must have sufficient water cover to permit the brook trout to spawn. The target levels in October and November are between 259.85 m to 259.80 m (852.6′ to 852.4′). At these levels, the maximum measured redd would likely not have sufficient water cover for brook trout to spawn at that location. This would result in 22 of the 23 redds typically being potential spawning sites.

After spawning, and until emergence, the brook trout redds must remain submerged or immersed in water to prevent the eggs and larvae from drying out and/or freezing. From the beginning of December through to the end of May, the penalty function target is to keep the water level at or above 259.49 m (851.4′). This level will protect 20 of the remaining 22 measured redds. Levels below this are less desirable.

Specific water level requirements for other fish species, including whitefish and lake trout, are not as restrictive as they are for Nipigon brook trout. Lake trout spawn on rocks and rubble on shoals often nearshore. However, they also spawn offshore in deeper water. Spawning depths range from about 0.3 m to greater than 20 m. Lake trout are reported to spawn at depths of less than 40 feet (12.2 m) and as shallow as one foot (0.3 m) in inland lakes and at depth of less than 120 feet (36.6 m) in the Great Lakes (Scott and Crossman, 1973). The lake trout spawning period is a little bit earlier than the brook trout. The lake trout emerge in mid-March to late April. At this time, the water levels are, on average, slightly higher than they are from late April to mid-May when the brook trout emerge. Lake levels which more closely mimic natural fluctuations should be beneficial for the lake trout.

Lake whitefish is the most sought after species commercially. They spawn on sand, gravel or rock shoals in depths from about 1.5 m to 15 m. Scott and Crossman (1973) report lake whitefish spawning depths to be generally less than 25 feet (7.6 m). The spawning period is from about mid-October to mid-November with emergence in mid-April to late May. As with the lake trout, target water levels that more closely mimic natural fluctuations should be beneficial for the whitefish.

The actual difference between the lake level in the fall (at spawning) and the following spring (at emergence) may be a more important factor for fall spawners, other than brook trout (such as whitefish and lake trout), than a specific level for spawning. The difference in fall and spring levels is known as "drawdown". The goal to optimize conditions for these fall spawners by attempting to match, as closely as possible, the natural variability of the drawdown.

Northern Pike spawn in shallow weedy areas from mid-April to late May with emergence in the later part of June. Water levels at this time are typically on the increase. There is still concern with the levels because a relatively small change can make a big difference. The approach of trying to mimic natural fluctuations should be beneficial for northern pike.

Excessively high water levels are a factor in causing erosion of the lake shoreline. This may result in increased turbidity of the water and siltation of the spawning areas. It is reasoned that placing an upper limit on the lake level will help to control erosion of the lake shoreline. There is no quantitative assessment of the cause and effect and it is not possible, at this time, to identify what specific levels may or may not result in significant additional erosion and what effects may or may not be seen. The penalty function target levels for May to September, based on anecdotal evidence from the *Draft Options Report*, were set at 259.49 m to 260.0 m (851.4' to 853.0') as being reasonable first estimates of appropriate levels. Level 260.6 m (855.0'), which is the present upper limit for Hydro, results in a penalty value of approximately 0.19.

The Lake Nipigon fish penalty functions are based on the best avalable data at this time. There is ongoing work on the Lake Nipigon fishery. Advances in our understanding of fishery issues, through research, will benefit future work in the Nipigon watershed.

3.2.3 Lake Nipigon Shoreline Property Owners and Users

<u>Summary</u>

The preferred range for shoreline property owners on Lake Nipigon from May to November is estimated to be 259.4 m (851.0') to 260.0 m (853.0'). The cost and/or inconvenience to the owners increases as the water level goes above or below this range. Recreational users of the shoreline have similar preferences. From December to April, no specific desired water levels have been defined. The penalty functions for the Lake Nipigon shoreline property owners and users are shown in Figure 3.2.

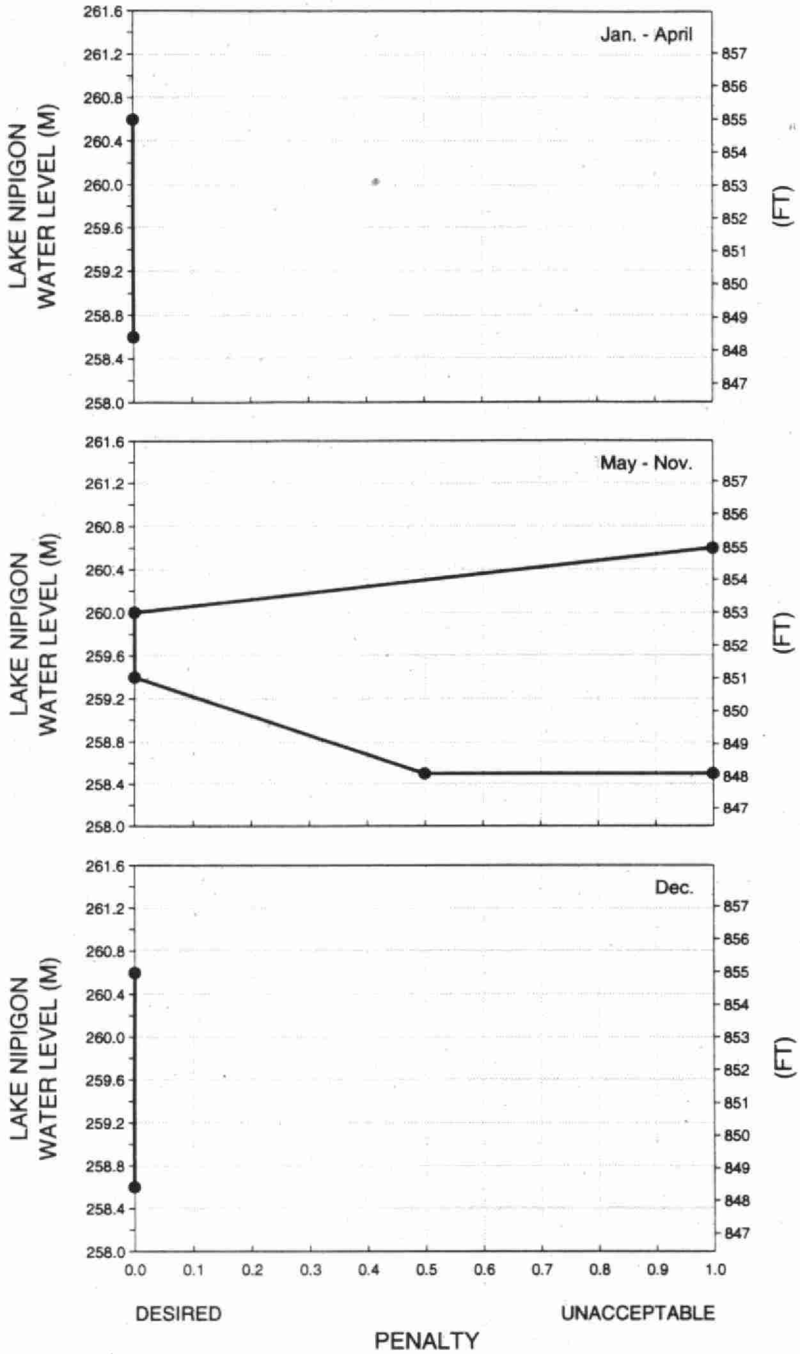
<u>Discussion</u>

Lake Nipigon shoreline property owners and users prefer water levels to:

a) be kept within a smaller range from the maximum to the minimum, especially during the summer months when use and enjoyment of their shoreline properties and recreational areas are at their greatest; and
b) remain below a certain threshold level to minimize erosion and damage to their properties, especially in the fall when storms are more prevalent.

Lake shoreline users say that it would be unacceptable to have a greater range of water levels than the present limits or to have an increased frequency of occurrence of high and/or low levels.

Figure 3.2 PENALTY FUNCTIONS FOR
LAKE NIPIGON
SHOREOWNERS, USERS, etc.



WATER LEVEL (M)	(FT)	PENALTY
258.60	848.4	0.00
260.60	855.0	0.00

WATER LEVEL (M)	(FT)	PENALTY
258.50	848.1	1.00
258.50	848.1	0.50
259.40	851.0	0.00
260.00	853.0	0.00
260.60	855.0	1.00

WATER LEVEL (M)	(FT)	PENALTY
258.60	848.4	0.00
260.60	855.0	0.00

Other lake users' interests are closely linked with the Lake Nipigon shoreline property owners including wildlife which is adversely affected by flooded shorelines (directly by not having the shoreline as a habitat; and indirectly through increased sedimentation caused by erosion of the shore), First Nation peoples who have traditional areas flooded, users of swimming beaches who see their beach widths diminished and beachcombers (including those from the charter boats) who have nowhere to walk when the shore is flooded. These other users will benefit if the Lake Nipigon water levels are maintained within a smaller range (lower the upper limit, raise the lower limit, or a combination of both). Therefore, these interests of the other users have been grouped with the interests of the Lake Nipigon shore property owners. This does nothing to restore areas that were flooded by the overall increase in the water level when the dams were originally built.

3.2.4 Lake Nipigon Boaters

Summary

Boaters on Lake Nipigon are affected by both low and high water levels. Low levels make launching more difficult and increase the danger of running aground on shoals. High levels result in more debris in the water. In general, the target water level is 260.0 m (853′) with some variations depending on the time of year. The penalty functions for Lake Nipigon boaters are shown in Figure 3.3.

Discussion

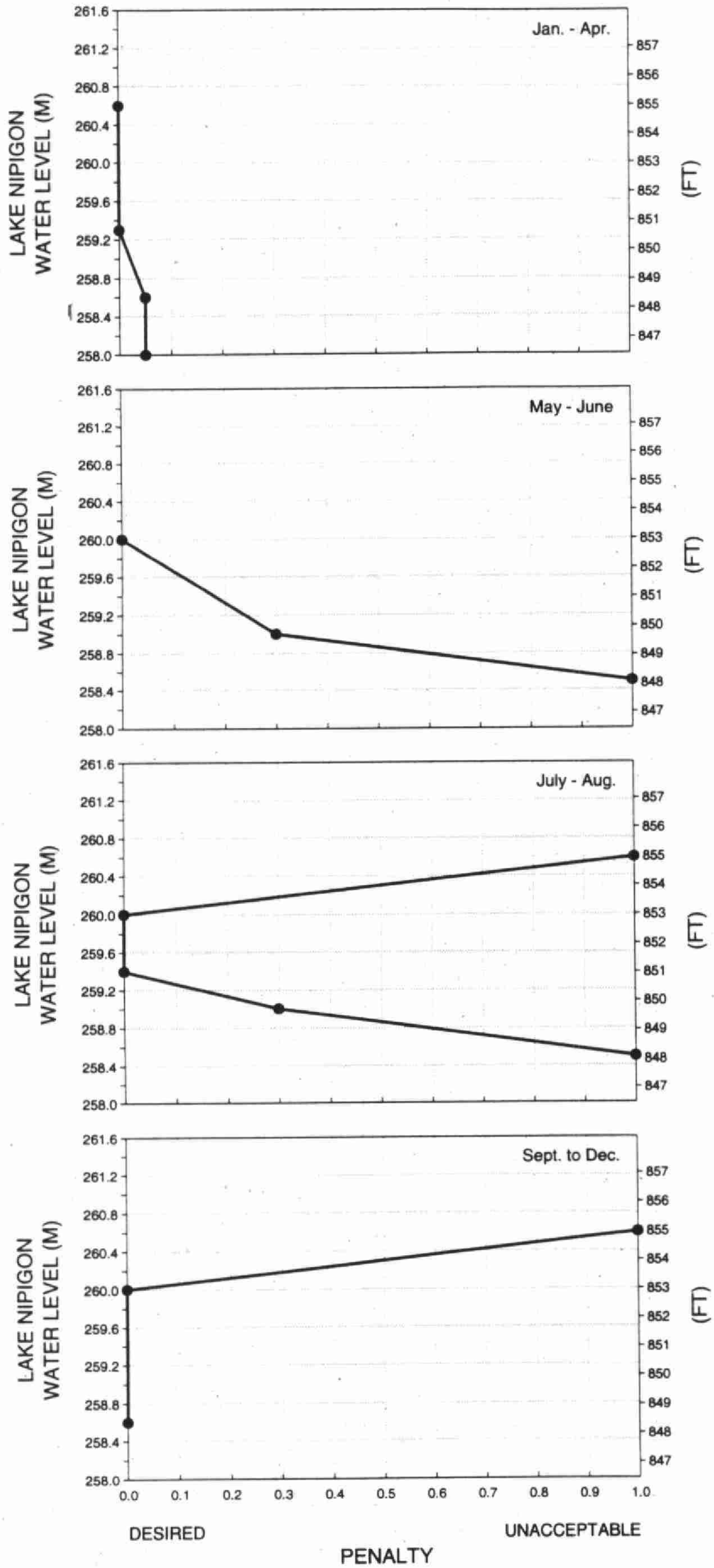
A target level of 260.0 m (853.0′) is set for May and June to provide good launching conditions. The penalty increases as the water level goes lower. No penalty has been assigned for higher water levels.

During the prime boating season of July and August, the target range of water levels is 259.4 m (850.9′) to 260.0 m (853.0′) with a penalty applied if the water level goes above or below this range. The target range was reported as a good range for safe, enjoyable boating.

In the fall, from September to December, the target is to keep the level at 260.0 m (853.0′) or lower. A penalty is applied only if the water level goes higher than 260.0 m (853.0′). This reflects the desire of boat owners to have as little debris in the water as possible, due to shore erosion at higher levels. Also, boat docks are more prone to damage during storms at higher water levels. Storms are more prevalent in the fall.

In the winter and early spring months of January to April, the target is to keep water levels above 259.3 m (850.7′) to minimize the occurrence of boats grounding. A relatively minor penalty is applied to water levels lower than the target.

Figure 3.3 PENALTY FUNCTIONS FOR
LAKE NIPIGON
BOAT OPERATORS



Jan. - Apr.

WATER LEVEL (M)	(FT)	PENALTY
257.00	843.2	1.00
258.00	846.4	0.05
258.60	848.4	0.05
259.30	850.7	0.00
260.60	855.0	0.00

May - June

WATER LEVEL (M)	(FT)	PENALTY
258.50	848.1	1.00
259.00	849.7	0.30
260.00	853.0	0.00

July - Aug.

WATER LEVEL (M)	(FT)	PENALTY
258.50	848.1	1.00
259.00	849.7	0.30
259.40	851.0	0.00
260.00	853.0	0.00
260.60	855.0	1.00

Sept. to Dec.

WATER LEVEL (M)	(FT)	PENALTY
258.60	848.4	0.00
260.00	853.0	0.00
260.60	855.0	1.00

3.2.5 Hydro-electric Power Generation

Summary

Ontario Hydro manages the water levels of Lake Nipigon by regulating the flow in the Nipigon River. The amount of electric power generated depends on the flow. The target flow for Ontario Hydro is a maximum flow of 390 m^3/s throughout the year. The penalty functions for hydro-electric power generation are shown in Figure 3.4. The flows represent the maximum flows during the peak electricity demand period of the day.

Discussion

From the sole perspective of hydro-electric power generation, the desired objective is to maximize the amount of electricity which is generated by the plants. The "zero" penalty of the penalty function is equivalent to the desired objective.

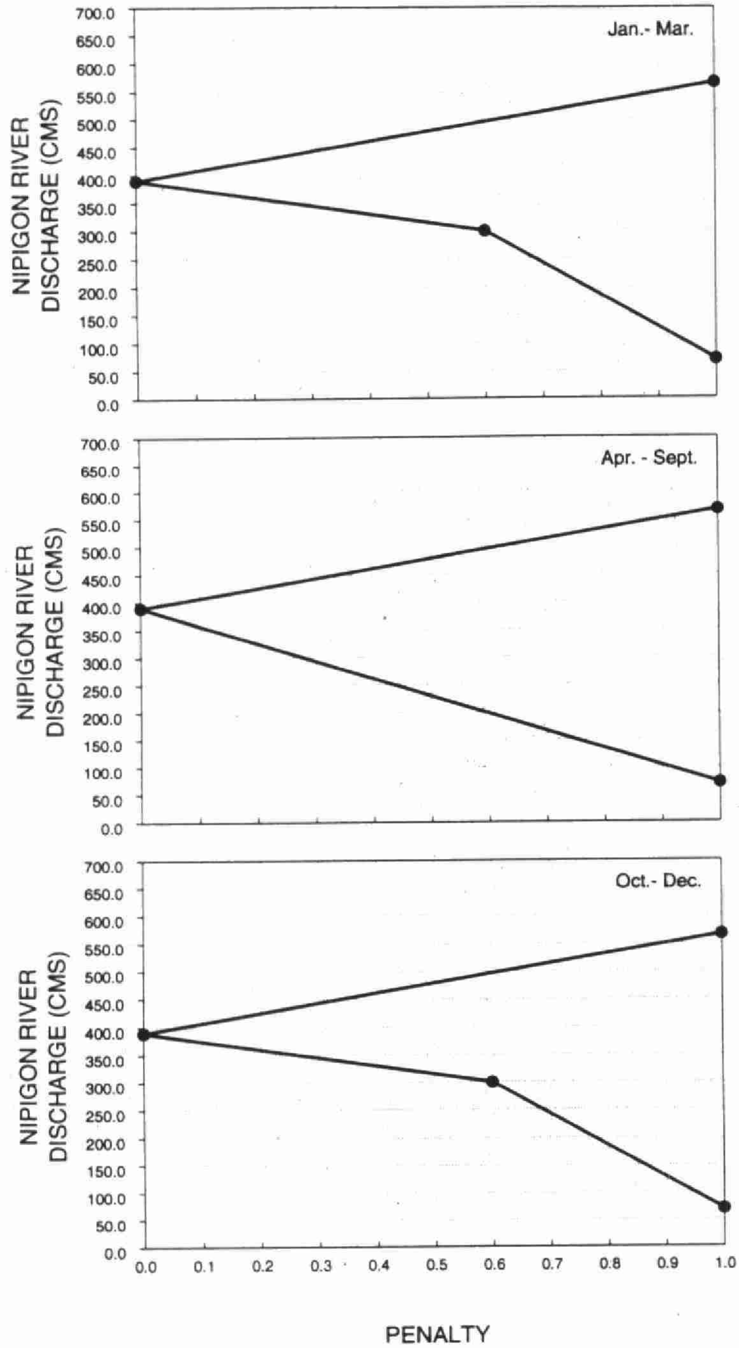
The nominal efficient capacity of the Nipigon generating stations as a system is 390 m^3/s. The nominal maximum generating capacity of the three Hydro stations, when they are being operated as one (i.e., no short-term storage of water in Jessie Lake) is 440 m^3/s. Flows greater than 390 m^3/s generate more electricity than at 390 m^3/s but not as efficiently. Flows greater than 440 m^3/s do not generate any more electricity than a flow of 440 m^3/s. When flow exceeds 440 m^3/s, that portion of the flow in excess of 440 m^3/s is "spilled" (i.e., the spilled flow is released downriver, bypassing the turbines, and it is not used to generate electricity). Spilling excess flow is considered to be a waste of that water's potential to generate power. The penalty increases as the flow increases above 390 m^3/s. The maximum penalty is 1.0 for a flow of 566 m^3/s which is the maximum flow considered to be safe for the railway bridge at Nipigon.

Flows less than 390 m^3/s generate less electricity. The minimum flow is 70 m^3/s which represents the capacity of one turbine. The minimum flow of 70 m^3/s is assigned the maximum penalty of 1.0 for the entire year.

During the higher demand period of October to March, generation is considered more important than during the period April to September. Therefore, to give more weight to winter power generation (during October to March), higher penalty values are assigned to given flows, below 390 m^3/s, during the winter than during the remainder of the year. For example, for a flow of 300 m^3/s, the winter penalty value is 0.60 and the penalty value during the rest of the year is 0.28.

The penalty function provided for hydro-electric power generation is not the only aspect of Ontario Hydro's operating policy for the Nipigon system. The penalty function is representative of only the hydro-electric power objectives. In the past Hydro has operated under directives that provide operating and absolute ranges for levels on Lake Nipigon. In addition, the Hydro directives have recognized concerns with high and low lake levels as well as flow rates on the Nipigon River. The present interim agreement is recognition of some of these concerns. Ontario Hydro operating procedures are further discussed in the Section 4.3 of the *Draft Options Report* (Atria, 1993).

Figure 3.4 PENALTY FUNCTIONS FOR
HYDRO ELECTRIC GEN. STATION
POWER i.e. ONTARIO HYDRO



DISCHARGE (CMS)	PENALTY
70.0	1.00
300.0	0.60
390.0	0.00
566.0	1.00

DISCHARGE (CMS)	PENALTY
70.0	1.00
390.0	0.00
566.0	1.00

DISCHARGE (CMS)	PENALTY
70.0	1.00
300.0	0.60
390.0	0.00
566.0	1.00

An important point to remember is that the natural water supply to the Nipigon basin plays the largest role in determining the lake levels and river flows. This is particularly evident during periods of high or low water inflow.

The "peaking" of the generating plants is discussed in Section 3.5.3. Peaking refers to the practice of increasing from minimum flows during the night, when demand for electricity is reduced, to maximum flows during the day, when demand for electricity is at its peak. The penalty functions refer to the maximum flow conditions during the day.

Ontario Hydro's plans to upgrade generating units at Cameron Falls GS, Alexander GS and Pine Portage GS will not have a significant impact on this study's computer modelling procedure. Hydro plans to upgrade Unit 7 (scheduled for 1995) at Cameron Falls GS, Units 4 (scheduled for 1997) and 5 (scheduled for 1998) at Alexander GS (A. Ansell, Ontario Hydro, pers. comm., November 30, 1993) and Units 1 and 2 (scheduled for 1996 and 1997) and Units 3 and 4 (scheduled for 2000 and 2001) at Pine Portage GS (S. Sears, Ontario Hydro, pers. comm., February 11, 1994). The work consists of the replacement of the existing turbine runners with more efficient runners. The result will be an increase in the efficiency of the stations and an increase in the stations' discharge. At Cameron GS, the increase in discharge is estimated by Hydro to be 3.5% at best efficiency and 1.8% at full power. At Alexander GS, Hydro's estimate of increased discharge is 1.5% and 1.3% at efficiency and full power respectively. The total increase in discharge is estimated to be 7.1% at efficiency for Pine Portage. Water levels at full power are expected to increase 4 cm (1.6 inches) at Cameron GS, 6.3 cm (2.5 inches) at Alexander GS and 7.2 cm (2.8 inches) at Pine Portage GS.

3.2.6 Nipigon River Brook Trout

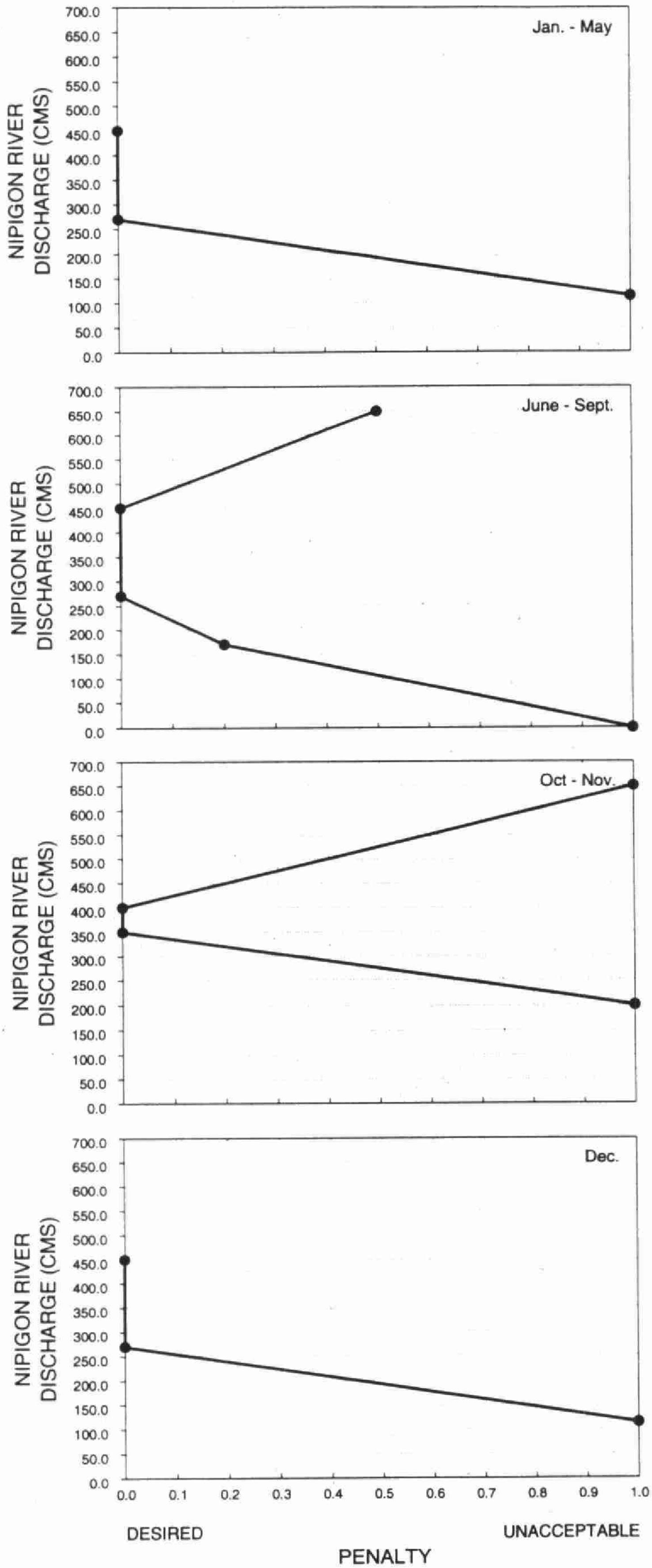
Summary

Brook trout on the lower Nipigon River require flows in the lower river to be greater than a certain minimum value such that the fish habitat is sufficiently submerged during the spawning, incubation and hatching period. This period extends from the beginning of October to the end of May. During the remainder of the year, the minimum flow can be decreased. The target flows for the Nipigon River brook trout are between 350 to 400 m^3/s in October and November, and greater than 270 m^3/s from December to the end of May. During the summer, from June to September, the target flow is between 270 and 450 m^3/s. The penalty functions for three different locations of Nipigon River brook trout are shown in Figures 3.5 to 3.7.

Discussion

As noted earlier, in the discussion regarding the Lake Nipigon brook trout penalty functions (see Section 3.2.2), brook trout have very specific spawning requirements, while the requirements of other fish species, such as chinook salmon and rainbow trout, are more flexible and adaptable. Therefore, at this stage the Study Team is proceeding on the basis that improving the water level regime in the river for brook trout spawning habitat will look after the water level requirements of the other fish species.

Figure 3.5 PENALTY FUNCTIONS FOR
BACKPOOL AT ALEXANDER GS
BROOK TROUT



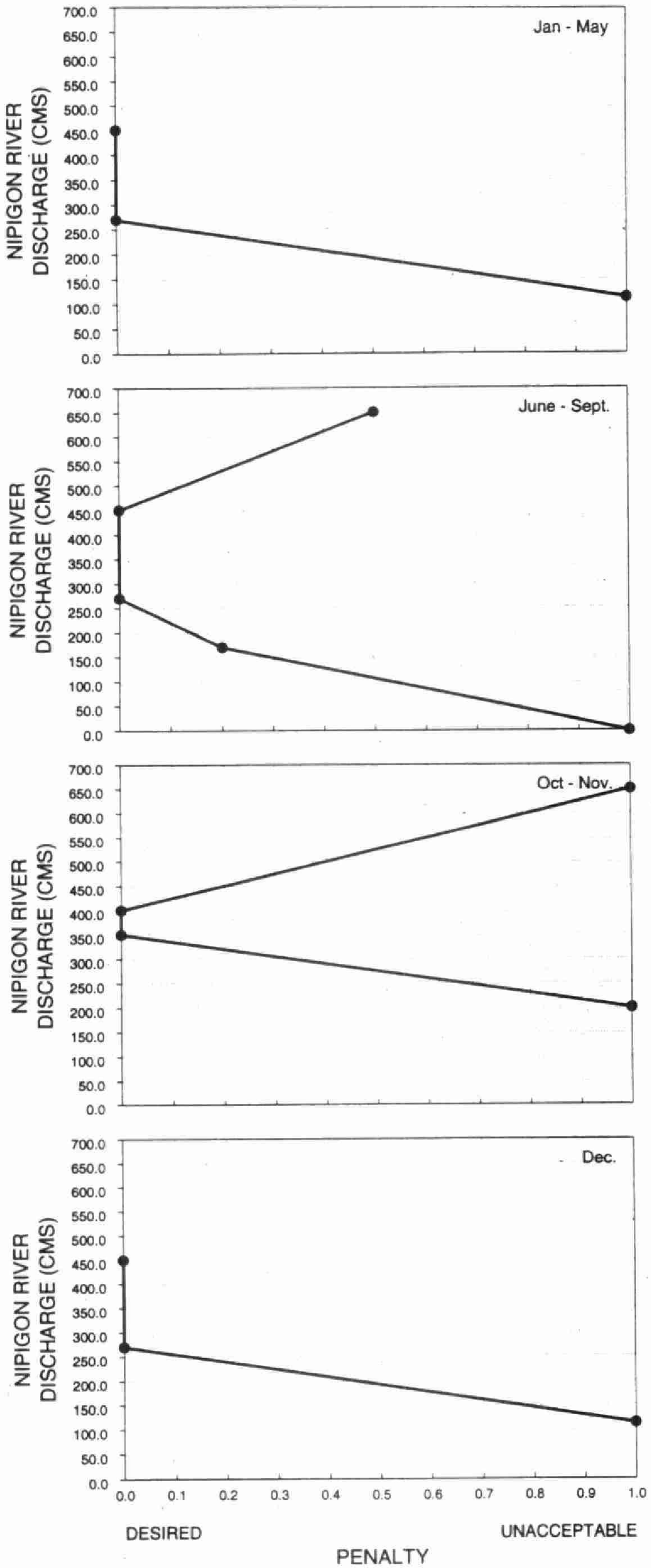
DISCHARGE (CMS)	PENALTY
113.0	1.00
270.0	0.00
450.0	0.00

DISCHARGE (CMS)	PENALTY
0.0	1.00
170.0	0.20
270.0	0.00
450.0	0.00
650.0	0.50
850.0	1.00

DISCHARGE (CMS)	PENALTY
200.0	1.00
350.0	0.00
400.0	0.00
650.0	1.00

DISCHARGE (CMS)	PENALTY
113.0	1.00
270.0	0.00
450.0	0.00

Figure 3.6 PENALTY FUNCTIONS FOR
PARMACHEENE
BROOK TROUT



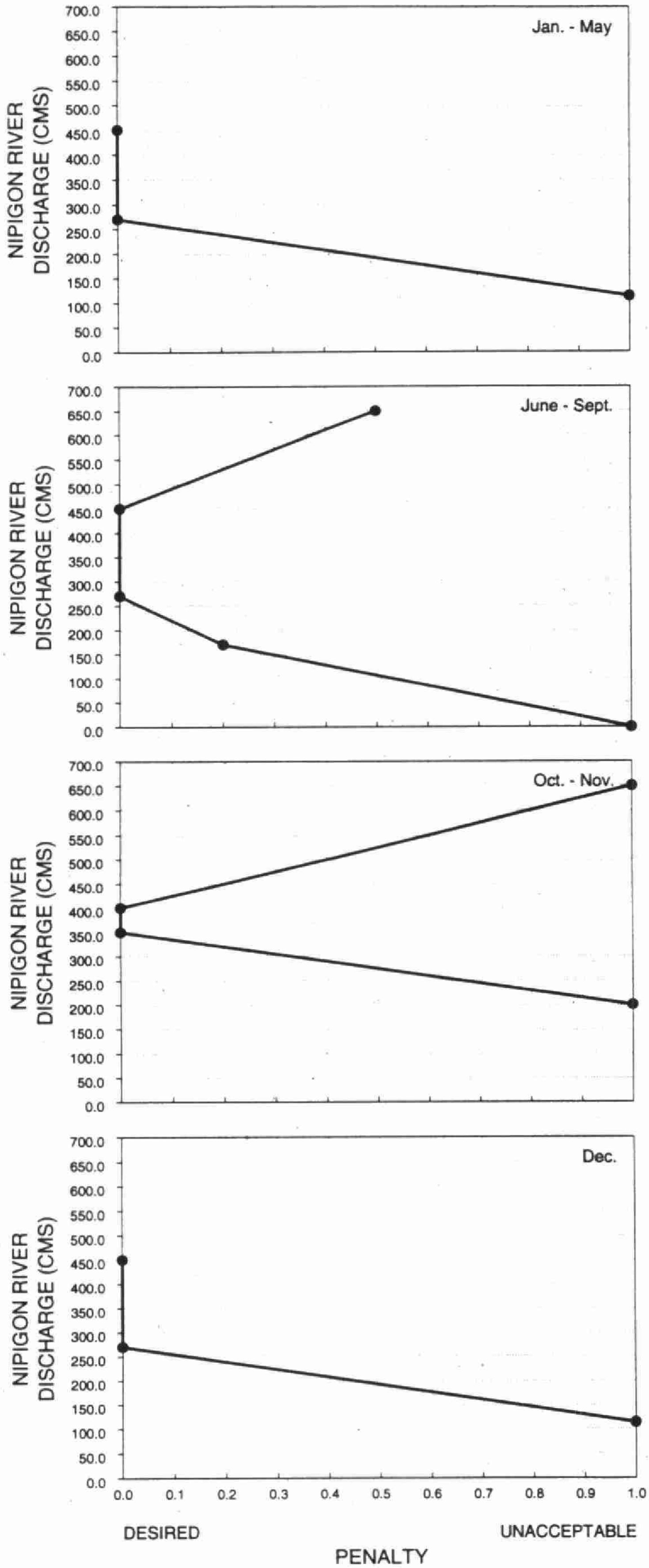
DISCHARGE (CMS)	PENALTY
113.0	1.00
270.0	0.00
450.0	0.00

DISCHARGE (CMS)	PENALTY
0.0	1.00
170.0	0.20
270.0	0.00
450.0	0.00
650.0	0.50
850.0	1.00

DISCHARGE (CMS)	PENALTY
200.0	1.00
350.0	0.00
400.0	0.00
650.0	1.00

DISCHARGE (CMS)	PENALTY
113.0	1.00
270.0	0.00
450.0	0.00

Figure 3.7 PENALTY FUNCTIONS FOR
GAPENS POOL
BROOK TROUT



Jan. - May

DISCHARGE (CMS)	PENALTY
113.0	1.00
270.0	0.00
450.0	0.00

June - Sept.

DISCHARGE (CMS)	PENALTY
0.0	1.00
170.0	0.20
270.0	0.00
450.0	0.00
650.0	0.50
850.0	0.00

Oct. - Nov.

DISCHARGE (CMS)	PENALTY
200.0	1.00
350.0	0.00
400.0	0.00
650.0	1.00

Dec.

DISCHARGE (CMS)	PENALTY
113.0	1.00
270.0	0.00
450.0	0.00

Reducing the range of river fluctuations would also benefit spring spawners, such as northern pike, and river benthos. Pike spawning habitat can be affected by small changes in the water levels if they are accessing marginally flooded weedy areas in the flood plain.

Other users' interests are closely linked with the Nipigon River fisheries. Wildlife that depend on the fish in the river, river benthos, First Nation subsistence fishermen, anglers (both local and tourist alike), and local tourist businesses (charter operators, restaurants, motels, suppliers) will benefit if the native Nipigon River fishery is healthy. In the *Draft Options Report* (Atria, 1993), it was noted that previous research has shown that rapid fluctuations of water levels in rivers downstream of power plants reduces the abundance, diversity and productivity of benthos. A healthy fishery dominated by native species is one indicator of a "healthy environment".

Brook trout in the Nipigon River select areas of groundwater discharge, or upwellings, as spawning and incubation habitat. These habitats occur in the nearshore zone where groundwater discharge to the river is maximized. Three specific brook trout redd locations have been identified in the lower Nipigon River: 1) Alexander Backpool; 2) Parmacheene; and 3) Gapens Pool. Elevations of brook trout redds and level/flow relationships at the three locations are provided in Section 4.5.4 of the *Draft Options Report* (Atria 1993). Note that on page 33 in the *Draft Options Report*, the last sentence in the first paragraph should read "the first redd becomes exposed at about 250 m^3/s."

Exposure of brook trout incubation habitat during the incubation period (December to April) should be avoided. Winter exposure can reduce groundwater flows and result in freezing of embryos within the substrate. Exposure of the brook trout incubation habitat during the alevin emergence period (April - May) should also be avoided. Curry et al. (1992) state that indications are that alevin survival will be compromised by exposure of the habitat.

Ontario Hydro (1993) has undertaken a laboratory study of the effects from redd dewatering under winter conditions on brook trout and whitefish egg and larval survival. Ontario Hydro states that their laboratory results "suggest that dewatering of brook trout larvae in near freezing conditions is less harmful than previously believed". Ontario Hydro wanted to proceed to full scale testing in the Nipigon River. Scientists from the Ministry of Natural Resources responded that the results of Hydro's work were insufficient to justify proceeding with Hydro's proposed river fluctuations and redd dewatering during the late winter and early spring (M. Ridgeway, MNR, pers. comm., November 30, 1993). A summary of Ontario Hydro's findings and correspondence between Hydro and the Ministry of Natural Resources is provided in Appendix D.

Most of the brook trout redds will remain submersed if the flow in the river is 270 m^3/s or greater. As flows decline below 270 m^3/s, an increasing number of redds become exposed. At 113 m^3/s, virtually all known redds are exposed.

During spawning in October and November, a target flow of 350 m^3/s to 400 m^3/s is considered to be adequate (R. Swainson, MNR, pers. comm.). The lower flow is specified to maintain sufficient water over the redds for spawning. The higher flow target is set to reduce the risk of the fish spawning too high up the shoreline. Typically, the flows from October to May could not be sustained at these high levels to protect the redds.

From June to September, the target flow is 270 m^3/s to 450 m^3/s.

It has been suggested by some of the lower river users that fluctuating levels and higher flows have resulted in erosion of the river banks thus increasing turbidity of the water and siltation of the spawning areas. However, there is no quantitative assessment of the cause and effect and it is not possible, at this time, to identify what exact flows may or may not cause erosion and what benefits may or may not be achieved. The upper penalty function target levels for June to November are based on anecdotal evidence and are used as reasonable first estimates of appropriate levels. It provides the model with some direction by recognizing that there is some negative impact to excessively high flows.

3.2.7 Lake Helen and Polly Lake Shoreline Property Owners and Users

Lake Helen and Polly Lake shoreline property owners and users and other shoreline property owners and users along the lower Nipigon River system prefer flows (and hence water levels) in the lower river to:

a) be more stable (i.e., fluctuations to be smaller in magnitude and to occur less rapidly), especially during the summer months when use and enjoyment of their shoreline properties and recreational areas are at their greatest;
b) remain below a certain threshold level to minimize erosion and damage to their properties, especially in the fall when storms are more prevalent; and
c) to stay above a lower limit to minimize adverse aesthetic conditions.

The penalty functions for Lake Helen and Polly Lake shoreline property owners and users are shown in Figure 3.8.

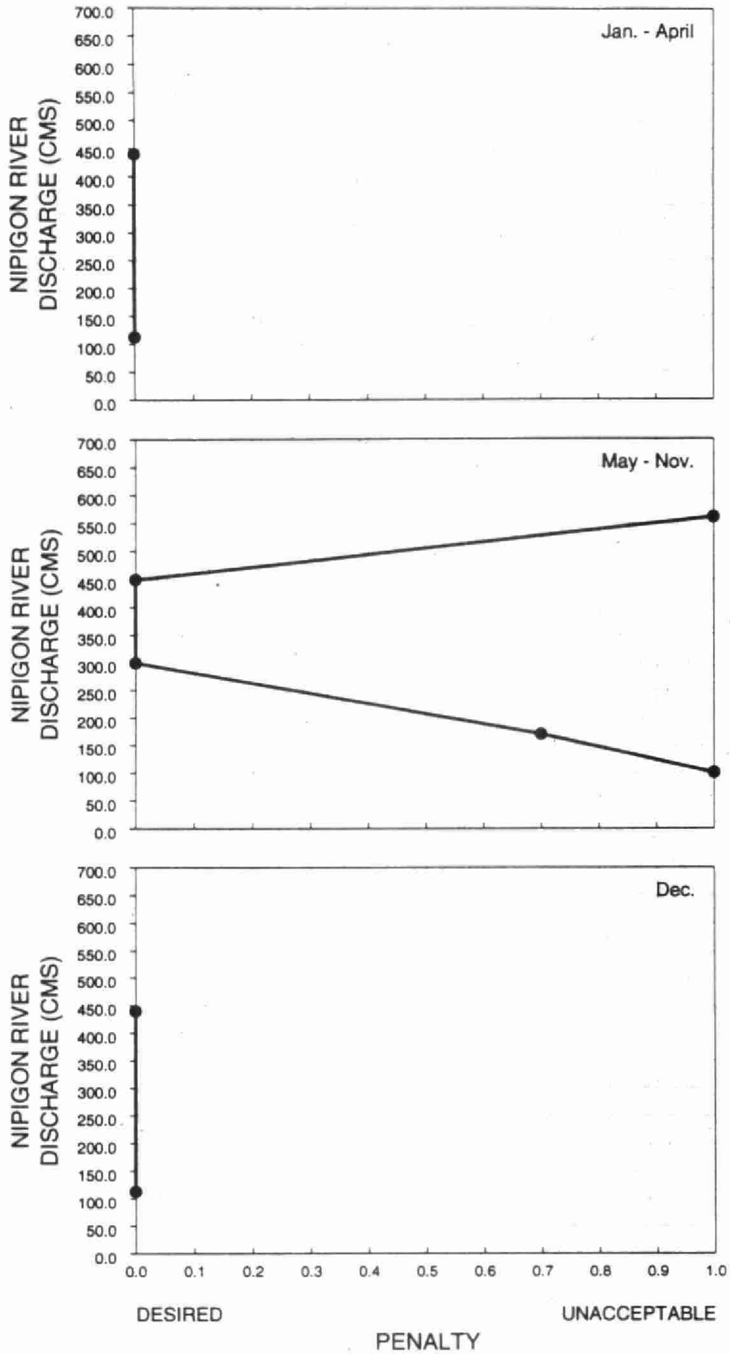
From May to November, the preferred range for shoreline property owners on Polly Lake and Lake Helen is a flow of 300 m^3/s (which is approximately equivalent to a level of ±184.0 m) to a flow of 450 m^3/s (approximately equivalent to a level of ±184.6 m). The preferred flow is about 375 m^3/s (level of ±184.3 m). Flooding of shoreline works will occur at about a flow of 560 m^3/s (level ±185.0). These are approximate values and they are also dependent on the level of Lake Superior. Further discussion of the relationship between the discharge from Pine Portage GS and the level of Lake Helen is provided in Section 3.5.2.

No specific penalty has been defined for flows during the remainder of the year.

3.2.8 Lake Helen/Nipigon River Boaters

Boaters on Lake Helen and the Nipigon River are affected by both low and high water levels. Low levels makes launching more difficult and increases the danger of running aground on shoals. High levels results in more debris in the water (see *Draft Options Report*, (Atria 1993))

Figure 3.8 PENALTY FUNCTIONS FOR
LAKE HELEN
SHOREOWNERS, USERS, etc.



DISCHARGE (CMS)	PENALTY
113.0	0.00
440.0	0.00

DISCHARGE (CMS)	PENALTY
100.0	1.00
170.0	0.70
300.0	0.00
450.0	0.00
560.0	1.00

DISCHARGE (CMS)	PENALTY
113.0	0.00
440.0	0.00

The preferred range of flows is the same as for the Lake Helen and Polly Lake shoreline property owners and users (see Section 3.2.7).

The penalty functions for Lake Helen and Polly Lake shoreline property owners and users are shown in Figure 3.9.

3.2.9 Town of Nipigon/ Red Rock Indian Band Water Supply

The Town of Nipigon water supply intake is affected (i.e., turbidity, water quantity) when the lower river flow drops below 180 m^3/s (level ±183.65 m at Gapens Pool). The water supply for the Red Rock Indian Band (Lake Helen reserve) is also affected by low river levels.

The penalty function for the Town and Band water supply is shown in Figure 3.10.

3.3 WEIGHTING FACTORS

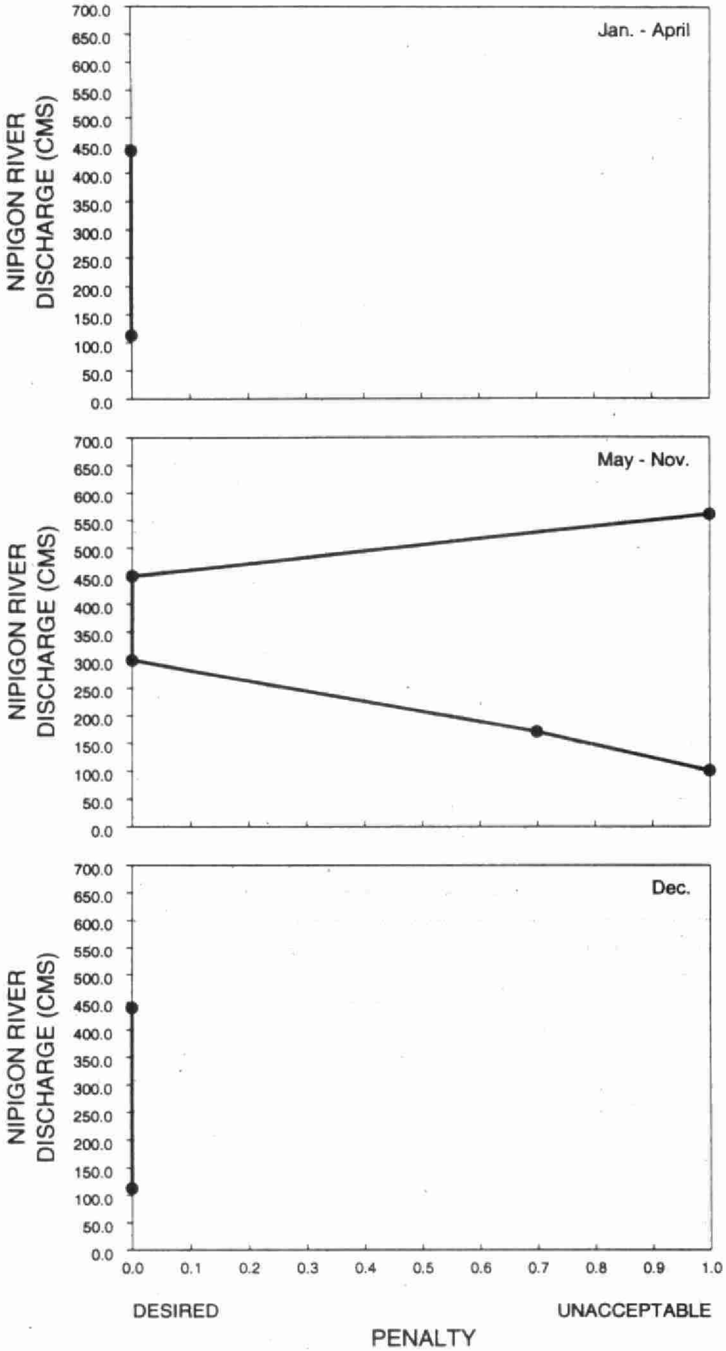
3.3.1 General Discussion

After the stakeholder penalty functions are established, the next step in the modelling procedure is to assign "weighting factors" to the penalty functions. Remember that the penalty functions represent what each of the various stakeholders wants in terms of water levels and flows. **The weighting factors reflect the relative importance of each of the stakeholders with respect to the other stakeholders.** For example, say there are four stakeholders, and say that the community has decided that the needs of the stakeholders are of equal importance. Therefore, in this case each stakeholder would be assigned an equal weighting factor of 25 percent for a total of 100 percent. However, say that the community decided that the requirements of two of the stakeholders were very important, the third was moderately important and the fourth was of relatively small importance. The weighting factors in this instance could then be say 40 percent for each of the first two stakeholders, 15 percent for the third and only 5 percent for the fourth for a total of 100 percent.

An "option" is then created by combining the stakeholder penalty functions together according to the weighting factors specified. Weighting factors can be varied to evaluate the sensitivity of the model to changes and to see which parameters are most significant.

The relative importance, or weight, of each of the stakeholder penalty functions is based on considerations of environmental impact, economic impact and distribution of impacts. Some improvements and damages can be quantified in dollars while others, particularly those related to environmental impacts, can not. As with any assessment, there will be some uncertainties in measurement techniques and reliability of data and some value judgements have to be made.

Figure 3.9 PENALTY FUNCTIONS FOR
LAKE HELEN
BOAT OPERATORS

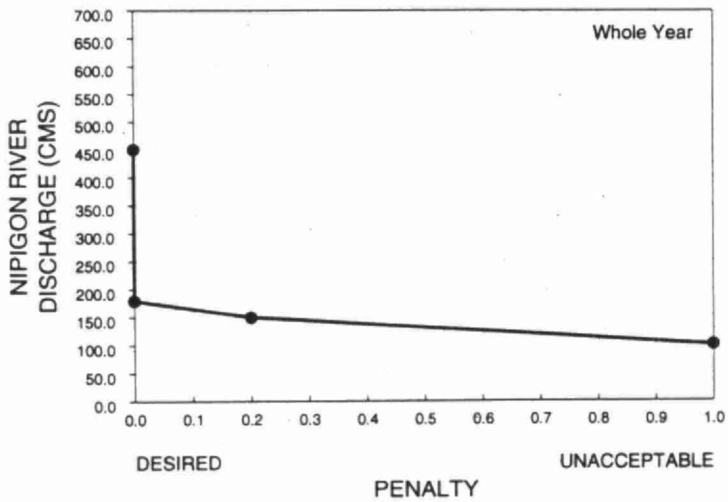


DISCHARGE (CMS)	PENALTY
113.0	0.00
440.0	0.00

DISCHARGE (CMS)	PENALTY
100.0	1.00
170.0	0.70
300.0	0.00
450.0	0.00
560.0	1.00

DISCHARGE (CMS)	PENALTY
113.0	0.00
440.0	0.00

Figure 3.10 PENALTY FUNCTIONS FOR
GAPENS POOL
NIPIGON WATER SUPPLY



DISCHARGE (CMS)	PENALTY
100.0	1.00
150.0	0.20
180.0	0.00
450.0	0.00

Considerations for establishing the weighting factors include environmental and economic impacts and the distribution of the impacts. The environmental concerns primarily included consideration of the impacts on: the number, health, diversity and sustainability of native fish, animal and plant communities; the water quality; and the shoreline, wetland and other habitat areas. The economic impacts of concern are: the cost of hydroelectric power generation; the revenue from commercial fishing; the flood and erosion losses and damages to property; the cost to water supply facilities; the tourism value, including beach use, anglers, charter operators and boating. With respect to the distribution of impacts, the objective is to ensure that no region or interest group is subjected to undue hardship.

3.3.2 Nipigon Weighting Factors

The responses on the limited number of comment sheets that were submitted following the public meetings and the discussions by the community-based Working Group and the Nipigon River Management Committee generally suggested a similar relative weighting, or ranking of importance. Table 3.1 summarizes the relative weighting provided by the three groups.

Table 3.1 Relative Weighting of Stakeholders

Stakeholder (Lake Nipigon and Nipigon River)	**Public Meeting Comment Sheets** (limited response)	**Working Group***	**Management Committee***
Fish and spawning habitat	high	1	1
Cost of electricity	moderate to low	3	2
Shoreline owners and users	moderate	2 to 3	3
Boaters	moderate	4	5
Nipigon water supply	not specified	5	5

* Out of a scale of 1 (higher importance) to 5 (lower importance)

The Working Group expressed the view that the weighting factors should reflect the future potential of a stakeholder and also the ability of a stakeholder to adjust to the conditions. They were concerned that fish can not adapt quickly to changes which are aggravated by constant fluctuations. The Working Group indicated that boaters can react much more readily to changing water levels

than other stakeholders. Cottagers were considered to be somewhat more of a concern than boaters in that they could not adapt as readily as boaters but that cottagers were not as significant as the fisheries. The Working Group commented that the Town could relocate its intake pipe but it was also recognized that there would be a construction cost associated with this alternative.

3.4 OPTIONS

3.4.1 General

An option is developed by combining the stakeholder penalty functions in accordance with the assigned weighting factors. In this report different options are generated by assigning different combinations of weighting factors to the penalty functions. The conceptual options presented in the *Draft Options Report* (Atria, 1993) are discussed in Section 3.4.2. The specific options evaluated in this report are described in Section 3.4.3.

3.4.2 Previous Options

During the first year of this study, it was found (*Draft Options Report* (Atria 1993)) that there are conflicts between:

1) those who want to stabilize the river flows versus those who want to stabilize the fluctuations in the lake levels; and

2) those who want a narrower specified minimum and maximum range of flows and levels versus Ontario Hydro which wants a wider operating range so that water is available when needed, in the desired quantity.

The five preliminary options presented in the *Draft Options Report* were conceptual in nature and were intended to represent the different sides of the conflict. These five options can be related to the penalty functions and weighting factors proposed in this report as follows:

Option 'A' - high weighting factor for Nipigon River brook trout penalty function;
Option 'B' - similar to 'A', but with additional restriction on peaking (going from maximum to minimum flows);
Option 'C' - highest weighting factor for hydro-electric power generation penalty function and a lower factor given to Nipigon River brook trout;
Option 'D' - highest weighting factor for the upper limit of Lake Nipigon shoreline owners and users penalty function; and
Option 'E' - highest weighting factor given to the Lake Nipigon fish penalty function with a somewhat lower factor assigned to the Lake Nipigon shoreline owners and users.

In this report, reference is no longer made to Options 'A' to 'E'. The more specific options now under consideration are discussed in the following Section 3.4.3.

3.4.3 Description of the Options

The options that were optimized and simulated in this report are presented in this section. The options are based on the weighting factors assigned to each stakeholder penalty function. Weighting factors are out of 100 (expressed as a percentage). When a stakeholder is not listed in an option, that stakeholder penalty function has been assigned a weighting factor of zero. In this manner, options can be examined that represent only one stakeholder (say for example, 100 percent Nipigon River brook trout), or three stakeholders (say for example 33⅓ percent Lake Nipigon fish, 33⅓ percent Nipigon River brook trout and 33⅓ percent hydro-electric power generation) or any other number of combinations of stakeholders.

Table 3.2 provides a summary of the options including the weighting factors and the maximum and minimum flow restrictions. Peaking is described in Section 3.5.3. For quick reference, each option has been assigned an acronym (see "Option" column in Table 3.2) based on some of the key letters in the description (see bolded letters in "Description" column in Table 3.2).

All the options, unless otherwise specified, are based on maintaining a minimum flow, when possible, in the Nipigon River of 270 m^3/s from October to May and 170 m^3/s from June to September. This is representative of the present interim flow agreement. Minimum flow restrictions limit how low the flows can be dropped during the periods of reduced electricity demand (i.e., the "off-peak" period from midnight to 7:00 a.m.). Increasing the flow from the minimum value at night to the maximum value during the day (to meet peak energy demands from 7:00 a.m. until midnight) is referred to as "peaking". Peaking is discussed further in Section 3.5.3.

Option OBS 110

Option OBS 110 represents the historically observed average weekly Lake Nipigon water levels and Nipigon River flows from 1951 to 1986 (refer to plots of levels and flows, Appendix F). Option OBS 110 was set with an minimum flow restriction of 170 m^3/s for weeks 23 to 39 of the year (nominally June to September) and 110 m^3/s (approximately equal to 113 m^3/s) for the rest of the year. This option is indicative of the restrictions on minimum flow prior to the interim flow agreement.

The interim flow agreement was discussed in the *Draft Options Report* (Atria, 1993). Essentially it requires Ontario Hydro to maintain a minimum instantaneous flow of 270 m^3/s from October through to May 15 and 170 m^3/s for the remainder of the year. Prior to interim agreement, Ontario Hydro attempted to maintain a minimum average daily flow of 113 m^3/s from October to April and a minimum average daily flow of 170 m^3/s from May to September. The hourly minimum discharge could go down to 70 m^3/s providing the daily average could be satisfied.

Table 3.2 Summary of Options

Option	Description	Weighting Factors
OBS 110	**OBS**erved data (1951-1986) with minimum flow of **110** m^3/s from October to May and 170 m^3/s from June to September.	not applicable
RIVFISH	Nipigon **RIV**er **FISH** (brook trout) most important consideration. Try to maintain River flows between 350 m^3/s & 400 m^3/s in October & November and above 270 m^3/s from December to September.	•100% Nipigon River brook trout.
LAKEFISH	**LAKE** Nipigon **FISH** most important consideration. More closely mimic natural Lake Nipigon average fluctuations by trying to get levels between 259.85 m & 259.8 m (852.6' & 852.4') during October & November, between 259.8 m & 259.49 m (852.4' & 851.4') from December to May and between 259.49 m & 260.0 m (851.4' & 853') from June to September.	•100% Lake Nipigon fish.
HYDRO	**HYDRO**-electric power generation most important consideration. Try to maintain maximum daily River flow at 390 m^3/s throughout the year.	•100% hydro power generation.
FISH	Equal consideration given to **FISH** from Lake and River (brook trout).	•50% Lake Nipigon fish •50% Nipigon River brook trout.
HYDFISH	Equal consideration given to **HYD**ro and Lake and River **FISH**.	•33⅓% Lake Nipigon fish •33⅓% Nipigon River brook trout •33⅓% hydro power generation.
OPT4	**OPT**ion combining the interests of various stakeholders with equal consideration to River and Lake interests and with a high importance placed on fish on both the River and the Lake.	•45% Lake Nipigon fish •35% Nipigon River brook trout •10% hydro power generation •5% each to Lake Nipigon and Lake Helen shore owners/users
OPT5	**OPT**ion combining the interests of various stakeholders, similar to OPT4 but with greater emphasis on Lake fish.	•60% Lake Nipigon fish •25% Nipigon River brook trout •10% hydro power generation •2.5% each to Lake Nipigon and Lake Helen shore owners/users

Note: All the options, unless otherwise specified, are based on maintaining a minimum flow, when possible, in the Nipigon River of 270 m^3/s from October to May and 170 m^3/s from June to September.

The interim agreement was intended as a short-term arrangement to provide some immediate protection to the Nipigon River brook trout habitat. It was recognized that a review of the effects of the agreement on other stakeholders would be necessary before determining if the agreement was viable over the long-term.

Option OBS 110 represents the "do nothing" approach or maintaining the status quo prior to the interim flow agreement between MNR and Ontario Hydro. The average lake levels and the average river flows are the actual recorded values. However, the maximum and minimum river flows represent the potential conditions which could have existed if Hydro had decreased the flow down to the allowable minimum flow values specified every day when necessary.

Option RIVFISH

Option RIVFISH provides a weighting of 100 percent to the interests of brook trout on the lower Nipigon River. No other stakeholders are explicitly given any consideration.

This option essentially tries to maintain the average weekly river flow between 350 m^3/s and 400 m^3/s during spawning in October and November and a flow above 270 m^3/s during the incubation and hatching period from December to May. In June through to September, the goal is to keep the average flow between 270 m^3/s and 450 m/s.

The minimum flow is restricted to 270 m^3/s from October to May and 170 m^3/s for the remainder of the year.

Option LAKEFISH

Option LAKEFISH provides a weighting of 100 percent to the interests of fish on Lake Nipigon. No other stakeholders are explicitly given any consideration.

The goal of this option is to maintain the average weekly level of Lake Nipigon between 259.85 m to 259.80 m (852.6′ to 852.4′) during the fall spawning in October and November. From December to May, the target level is between 259.80 m to 259.49 m (852.4′ to 851.4′). From June to September, the target is that water levels be above 259.49 m (851.4′) and below 260.0 (853.0′).

Option HYDRO

Option HYDRO provides a weighting of 100 percent to the interests of hydro-electric power generation. No other stakeholders are explicitly given any consideration.

This option tries to maintain the maximum daily river flow at 390 m^3/s throughout the year. The resulting daily average flow is based on the specified minimum flow restrictions. The relationship between maximum, average and minimum flow is presented in Section 3.5.3.

The HYDRO option is not the only aspect of Ontario Hydro's present or past operating policies for the Nipigon system. The HYDRO option is representative of only the hydro-electric power objectives. In the past, as discussed in Section 3.2.5, Hydro has operated under directives that provide operating and absolute ranges for levels on Lake Nipigon. In addition, the Hydro directives have recognized concerns with high and low lake levels as well as flow rates on the Nipigon River.

As stated earlier in this section, all the new options have a minimum flow restriction of 270 m^3/s from October to May and 170 m^3/s for the remainder of the year. The choice of the same minimum flow restrictions for all the new options provides a consistent basis for comparison. A discussion of other minimum flow restriction scenarios (i.e., 70 m^3/s throughout the year; and 110 m^3/s in the winter and 170 m^3/s in the summer) for the HYDRO option is provided in Section 4.2.

Option FISH

Option FISH equally weights (50 percent to each) the interests of fish in Lake Nipigon and brook trout in the lower Nipigon River. No other stakeholders are explicitly given any consideration.

This option attempts to balance the target lake levels and the target river flows, described in Options RIVFISH and LAKEFISH.

The minimum flow is restricted to 270 m^3/s from October to May and 170 m^3/s for the remainder of the year.

Option HYDFISH

Option HYDFISH equally weights (33⅓ percent each) the interests of brook trout on Lake Nipigon and in the lower Nipigon River and the interests of hydro-electric power generation. No other stakeholders are explicitly given any consideration.

This option attempts to balance the target lake levels and the target river flows, described in Options RIVFISH, LAKEFISH and HYDRO.

The minimum flow is restricted to 270 m^3/s from October to May and 170 m^3/s for the remainder of the year. As was noted previously under Option HYDRO, a discussion of the impact of this minimum flow restriction on Ontario Hydro is presented in Section 4.2.

Option OPT4

Option OPT4 provides 45 percent of the weight to fish on Lake Nipigon, 35 percent to Nipigon River brook trout, 10 percent to hydro-electric power generation and splits the remaining 10 percent equally between shore owners and users on Lake Nipigon and Lake Helen/Polly Lake (5 percent each). The other stakeholders were not given any explicit consideration.

Both the Nipigon River brook trout and the hydro-electric power generation penalty functions try to maintain flows above a certain level. This tends to lower the lake level. In order to counteract this, this option provides equal consideration to the interests on Lake Nipigon (50 percent) and the Nipigon River (50 percent). As well, brook trout on the Nipigon River are given three and one-half times more consideration than hydro-electric power generation. The relative importance of shore owners and users is rated as only one-seventh to one-ninth of brook trout on the river and fish in the lake respectively.

The minimum flow is restricted to 270 m^3/s from October to May and 170 m^3/s for the remainder of the year.

Option OPT5

Option OPT5 is a variation of OPT4. It provides 60 percent of the weight to fish on Lake Nipigon, 25 percent to Nipigon River brook trout, 10 percent to hydro-electric power generation and splits the remaining 5 percent equally between shore owners and users on Lake Nipigon and Lake Helen/Polly Lake (2.5 percent each). The other stakeholders were not given any explicit consideration.

Option OPT5 provides greater consideration to the interests on Lake Nipigon (62.5 percent) than the interests on the Nipigon River (37.5 percent). Brook trout on the Nipigon River are given two and one-half times more consideration than hydro-electric power generation. The importance of shore owners and users is considered to relatively small compared to fish.

The minimum flow is restricted to 270 m^3/s from October to May and 170 m^3/s for the remainder of the year.

3.5 OPTIMIZATION

3.5.1 General

Once an option has been identified, the next step is to develop an optimal strategy or plan for releasing water from Lake Nipigon to the Nipigon River for that specific option. The multi-objective optimization computer model determines the optimal operating strategy that minimizes the total penalty, or cost, to all of the stakeholders (based on the assigned weighting factors) as a group. The penalty functions are measures of the costs incurred by the different stakeholders for a range of water levels and flows. Minimizing the total penalty does not mean that each stakeholder's cost is necessarily minimized. In fact, one or more stakeholders may not see their costs minimized. However, for a given set of penalty functions and weighting factors (i.e, for a specific "option"), the strategy computed by the optimization model is the optimal strategy for that given set of penalty functions and weighting factors.

It should be noted that the penalty functions are merely good approximations of the costs incurred by the stakeholders. Also, the weighting factors are subject to some debate because who can really

know and articulate what a pluralistic society's preferences are? Thus, there is some uncertainty in the planning objective for this as well as any other water resources analyses. The purpose of optimization models is not to identify the single best solution, even if a single well defined planning objective could be agreed upon. Rather they are intended to eliminate those alternatives that are clearly inferior. Multi-objective analyses do not yield single optimal solutions, but are more useful at identifying the trade-offs among conflicting noncommensurable objectives. The selection of the "best compromise" solution from among those options with only marginal differences is, in the end, a management decision (Loucks et al. 1981).

3.5.2 Stochastic Dynamic Programming

The optimization computer model used in this study is referred to as a "stochastic dynamic programming" model. Dynamic programming is a mathematical technique which is often useful for making a sequence of interrelated decisions. It provides a systematic procedure for determining the combination of decisions that maximizes overall effectiveness. In statistics the word stochastic is synonymous with random, but in hydrology it has been used in a special way to refer to a time series which is partially random. Further discussion of the stochastic dynamic programming procedure is provided in Appendix E.

The model works on a weekly timestep and determines weekly average flow (i.e. daily average flow, constant flow for a week). Peaking is discussed in Section 3.5.3.

The Lake Nipigon/Nipigon River system is quite complex but it can be reasonably represented in an idealistic way in the model. Factors represented include the following:

- total inflow into the Lake Nipigon drainage basin including the Ogoki diversion (total inflow called Net Basin Supply);

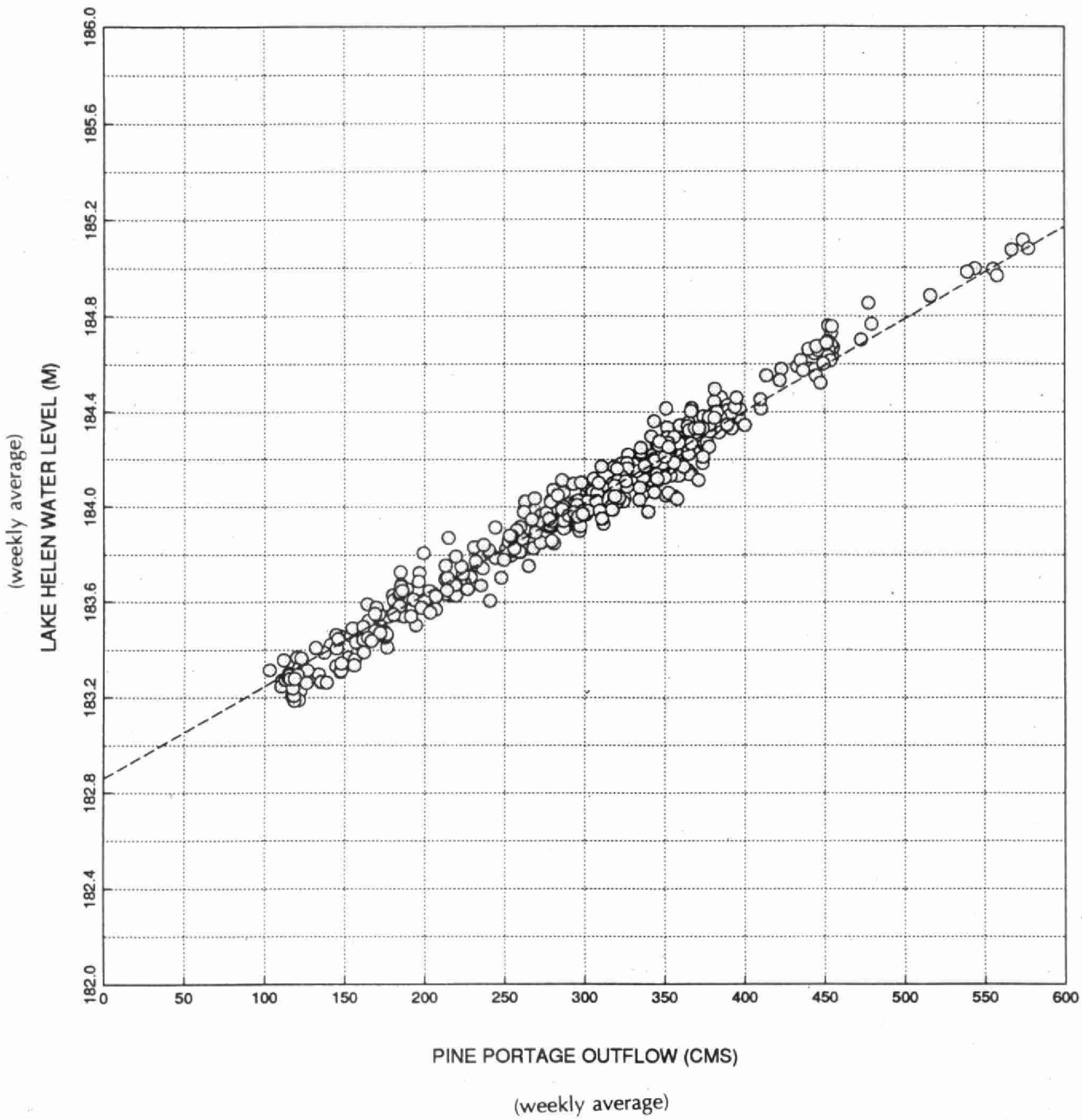
- flow in lower Nipigon River, represented by release at Pine Portage (assumed that all the generating stations act in unison); and

- level of Lake Helen (Polly Lake assumed to closely follow level of Lake Helen).

All the variables are linked by the hydraulics of the system, which is characterized by various storage-elevation (Lake Nipigon) and stage-discharge (Nipigon River) curves. Stage is another term for elevation or level. Discharge is the flow. Since weekly flow is considered, the weekly average water level of Lake Helen may be related to the weekly average discharge at Pine Portage GS as seen in Figure 3.11. The model now can be simplified as a single reservoir with a stochastic inflow component and outflow discharge (decision variable). All penalty functions are expressed in terms of water level at Lake Nipigon or outflow from Lake Nipigon.

Figure 3.11 Lake Helen Water Level vs. Discharge at Pine Portage GS

LAKE HELEN WL = 182.86 + 0.00385 * PINE PORTAGE OUTFLOW



Constraints built into the computer program include a minimum and maximum instantaneous discharge at Pine Portage of 70 m^3/s of 566 m^3/s respectively. One Alexander GS generating unit running at efficiency is 70 m^3/s. The maximum limit of 566 m^3/s has been set to safeguard the railway bridge at Nipigon. These limits match those set by Ontario Hydro's Technical Directives which govern their operation of the Nipigon system (Atria, 1993). The other constraints within the computer model are the lower and upper levels of Lake Nipigon which are 258.5 m (848.1') and 261.3 m (857.3') respectively. These lake limits are merely for the efficiency of the computer modelling. They were chosen as being the likely range of levels in which all model simulation would fall. These levels are not indicative of any change to the present lake level limits. Hydro's present absolute range on Lake Nipigon, as required by agreement, is 259.1 m to 260.6 m (850.1' to 855.0').

3.5.3 Peaking

To maximize the dependability and efficiency of the three hydro-electric generating plants (Pine Portage, Cameron Falls and Alexander), Ontario Hydro desires the minimum and maximum flow limits on the river to be as low and as high, respectively, as is reasonably possible. The minimum flow limit establishes how low the flows can be dropped during the periods of reduced electricity demand (i.e., the "off-peak" period from midnight to 7:00 a.m.). Increasing the flow from the minimum value at night to the maximum value during the day (to meet the peak energy demands from 7:00 a.m. until midnight) is referred to as "peaking". The greater the range between the minimum and maximum limits, the greater the potential for Hydro to carry out peaking operations. Peaking operations were described in the *Draft Options Report* (Atria, 1993).

As discussed in Section 3.4.3, prior to the MNR/Ontario Hydro interim flow agreement, the minimum instantaneous (hourly) flow was 70 m^3/s (provided the minimum daily average could be sustained). The maximum instantaneous limit is approximately 440 m^3/s (which is the nominal capacity of the stations without spilling water). The capacity at efficiency is 390 m^3/s. This maximum available range (from 70 m^3/s to 440 m^3/s) is more effective under low average daily or weekly flow conditions than high flow conditions. In fact, peaking is not possible under high flow conditions because the generating stations would already be operating at or near full capacity.

Peaking for power generation in the Nipigon River is implicity taken into account in the developed stochastic dynamic programming (DP) model. In the model, the peaking procedure in a day is assumed to be such that the maximum flow released from the Ontario Hydro generating stations will occur for 16 hours during the on-peak period, and then the released flow will be reduced to a minimum flow for 8 hours. The high flow during the on-peak period is referred to as the "maximum flow", Q_{max}, while the low flow after peaking is referred to as the "minimum flow", Q_{min}.

Hence, the daily average flow can be computed as

$$Q_{avg} = \frac{8}{24} Q_{min} + \frac{16}{24} Q_{max}$$

For power generation purpose, the on-peak maximum flow should be maximized. In theory, the minimum off-peak flow could be set to zero or close to zero. Subject to the constraints (i.e., minimum water levels for water supply intakes, fish habitat, boating) on the lower Nipigon River, downstream of the generating stations, the minimum flow could be maintained at a specific value without producing any adverse impacts downstream. In the stochastic DP model, the minimum flow is specified in the input and can be varied.

One of the objectives of the developed DP model is to optimize the maximum flow for hydro-electric power generation by minimizing the cost of associated penalty functions. Since the flow generated by the DP model is a weekly average flow (i.e. daily average flow, constant for a week), the maximum flow can then be calculated as

$$Q_{max} = 1.5\, Q_{avg} - 0.5\, Q_{min}$$

The penalty functions specified for Ontario Hydro are expressed as penalty versus flow, where the flow should be considered as Q_{max} rather than Q_{avg}.

The minimum flow, Q_{min}, specified in the options (see Section 3.4) is based on representative minimum daily average flows. In a given week, if the calculated average flow is less than the specified minimum flow, then the minimum flow for that week becomes equivalent to the average flow (i.e., there is no potential for peaking during that week).

It should be noted that the computer model considers only one on-peak period and one off-peak period per day (24 hours) and that these are constant for any given week. Also, the model assumes that the change in flow, from the maximum value during the on-peak period to the minimum value during the off-peak period, occurs instantaneously (i.e., in the hour from 11 p.m. to midnight, the flow is at its maximum and then from midnight to 1 a.m., the flow is at its minimum). These model arrangements are necessary simplifications of the actual operation of the hydro dams. In reality, there is also a peaking consideration from weekdays to the weekend. In addition, arrangements between Ontario Hydro and MNR place some restrictions on how rapidly the flow can be decreased from maximum to minimum. Various restrictions were discussed on page 70 of the *Draft Options Report* (Atria, 1993). Subsequent to that report, the Study Team was advised (B. Lomenda, Ontario Hydro, pers. comm.) that the initial reduction in flow could be 100 m^3/s with a further 50 m^3/s reductions every 2 hours.

Further discussion of the operational aspects of peaking, as well as the protocol for emergency shutdowns (i.e., equipment failures, oil spills) and courtesy flow reductions (i.e., canoe races, placement of navigational buoys) will be provided in the *Final Report*.

3.6 SIMULATION

Once an optimal operating strategy for each option has been obtained, the historically observed net basin supply data from 1951 to 1986 is used to simulate the average weekly level of Lake Nipigon and the average weekly flows in the Nipigon River. Net basin supply is the sum of all water inputs to the Nipigon watershed including the Ogoki diversion. The 1951 to 1986 period reflects conditions after construction of last generating station (Pine Portage) in 1950. The latest net basin supply data available was 1986.

The simulated time series of weekly average lake levels and river flows can then be compared with the observed data. The weekly average lake levels can be directly compared with the observed levels. Weekly lake levels are good representations of the lake levels. The lake level does not vary significantly on a day to day basis except during storms.

Due to the practice of peaking the river flows from minimum to maximum, the time series simulated weekly average flows (can also be considered as daily average flow constant for a week) are not very representative of the range of flows that can be experienced on a daily basis. Therefore the time series of average simulated flows were processed, according to the relationship described in Section 3.5.3, to provide potential maximum and minimum values. The process (follows the optimization and the simulation), on a weekly basis, works as follows:

> The average simulated flow is provided by the simulation procedure following the optimization. The minimum flow is set by the specified minimum flow restriction and the maximum flow is determined by
>
> $$Q_{max} = 1.5\,Q_{avg} - 0.5\,Q_{min}$$
>
> For example, say the average simulated flow, Q_{ave}, in a given week was 300 m^3/s and the specified minimum flow restriction, Q_{min}, was 270 m^3/s. Therefore, the maximum flow, Q_{max}, would be 315 m^3/s (i.e., 1.5*300-0.5*270).
>
> However, if the resultant Q_{max} is greater than 440 m^3/s, Q_{max} is set equal to 440 m^3/s and Q_{min} is then determined. This is done because Hydro does not need to peak to a maximum value greater than 440 m^3/s. For example, if Q_{ave} is 370 m^3/s, and the original specified minimum flow restriction was 170 m^3/s, the initial resulting Q_{max} would be 470 m^3/s which is greater than 440 m^3/s. Therefore, Q_{max} would be set to 440 m^3/s and the resulting Q_{min} would increase to 230 m^3/s.

If the simulated average flow, Q_{ave}, is less than the specified minimum flow restriction in a given week, the minimum flow, Q_{min} for that week becomes equivalent to the average flow. For example, say the average simulated flow was 100 m^3/s in a given week and the specified minimum flow restriction was 170 m^3/s. Therefore for that week, the minimum flow would become equal to the average flow (i.e., Q_{min} would be set to 100 m^3/s). Thus the maximum flow would also be the same as the average flow. This demonstrates that the minimum flow restriction only prevents the minimum flow from going below the specified limit when there is enough water in the Nipigon system. During low inflow conditions (i.e. extremely dry year), there may be times when the flow in the river drops below the minimum flow restriction.

If the simulated average flow, Q_{ave}, is greater than 440 m^3/s in a given week, the minimum flow for that week, Q_{min} and Q_{max} for that week become equivalent to the average flow. For example, say the average simulated flow was 500 m^3/s in a given week, the minimum and maximum flows for that week would also be 500 m^3/s.

The simulated time series of weekly average lake levels and the minimum and maximum river flows can then used to compare what potentially would have happened between 1951 and 1986 (i.e., the observed data with the specified minimum flow restrictions) and what would have happened over the same time period if the simulated option had been in place.

4.0 SIMULATION OF THE OPTIMIZED OPTIONS

4.1 PRESENTATION OF THE RESULTS

The summarized optimization and simulation results for each of the options (described in Section 3.4.3) are presented in this section. Detailed results are presented in Appendix F. The following sub-sections describe the type and format of the results. Sections 4.2 and 4.3 evaluate and compare the results.

The options are simulations and are not exact predictions of what will happen. However, they do provide a good indication of the relative impacts of the options based on the best available data. There will continue to be periods of high and low lake levels and river flows.

Time Series of Levels and Flows (refer to Appendix F)

Time series, from 1951 to 1986, of the simulated weekly average Lake Nipigon water levels and Nipigon River flows, for each option, are presented in Appendix F. An example of the time series for Option OPT5, from 1971 to 1980, is presented in Figure 4.1. The lake levels are at the top half of the page and the river flows are at the bottom half. The weekly average river flows can be considered as daily average flows, constant for a week. The simulated option is represented by the dashed line. For comparison purposes, the observed average weekly data (Option OBS 110) is also plotted (solid line).

Performance of Options Relative to Penalty Functions (refer to Appendix F)

Three sets of figures detailing how each of the eight options performed relative to the stakeholder penalty functions (refer to Section 3.2) are presented in Appendix F as follows:

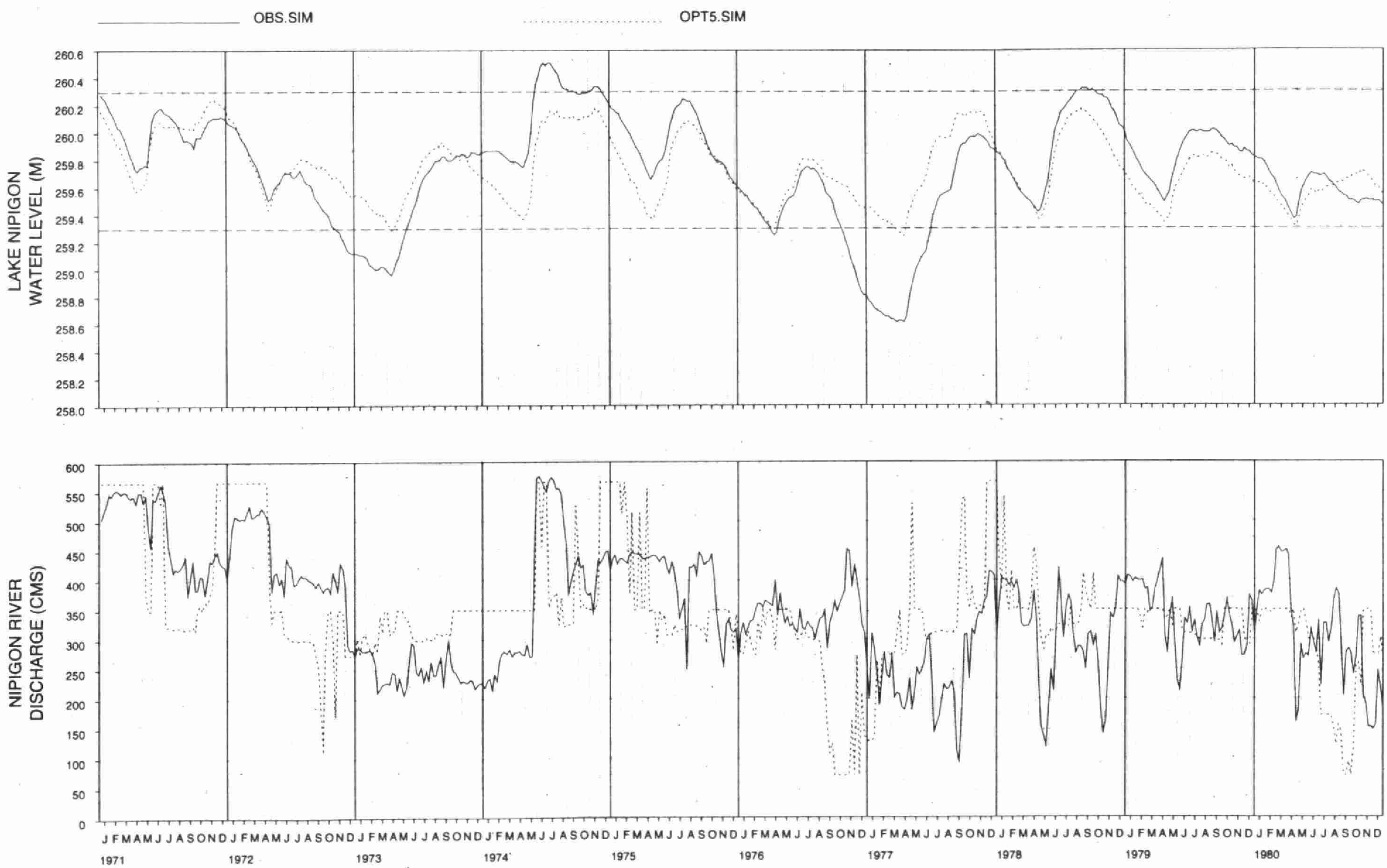
1) average level (Lake Nipigon) or flow (Nipigon River) (see Figure 4.2 for example);
2) maximum flow (Nipigon River) (see Figure 4.3 for example); and
3) minimum flow (Nipigon River) (see Figure 4.4 for example).

In the figures, the terminology "expected range" is synonymous with target level or flow or desired level or flow.

Figures 4.2, 4.3 and 4.4 are the results for Option OPT5 and represent example outputs.

Lake Nipigon stakeholders are not included in the maximum and minimum flow figures (see Figures 4.3 and 4.4 respectively) because the level of the lake depends only on the average flow. It should be noted (as discussed in Section 3.6) that in cases when the average flow is less than the specified minimum flow restriction, the minimum flow will be equal to the average flow (i.e., there would be no peaking).

Figure 4.1 SIMULATED WEEKLY FLOWS AND LEVELS



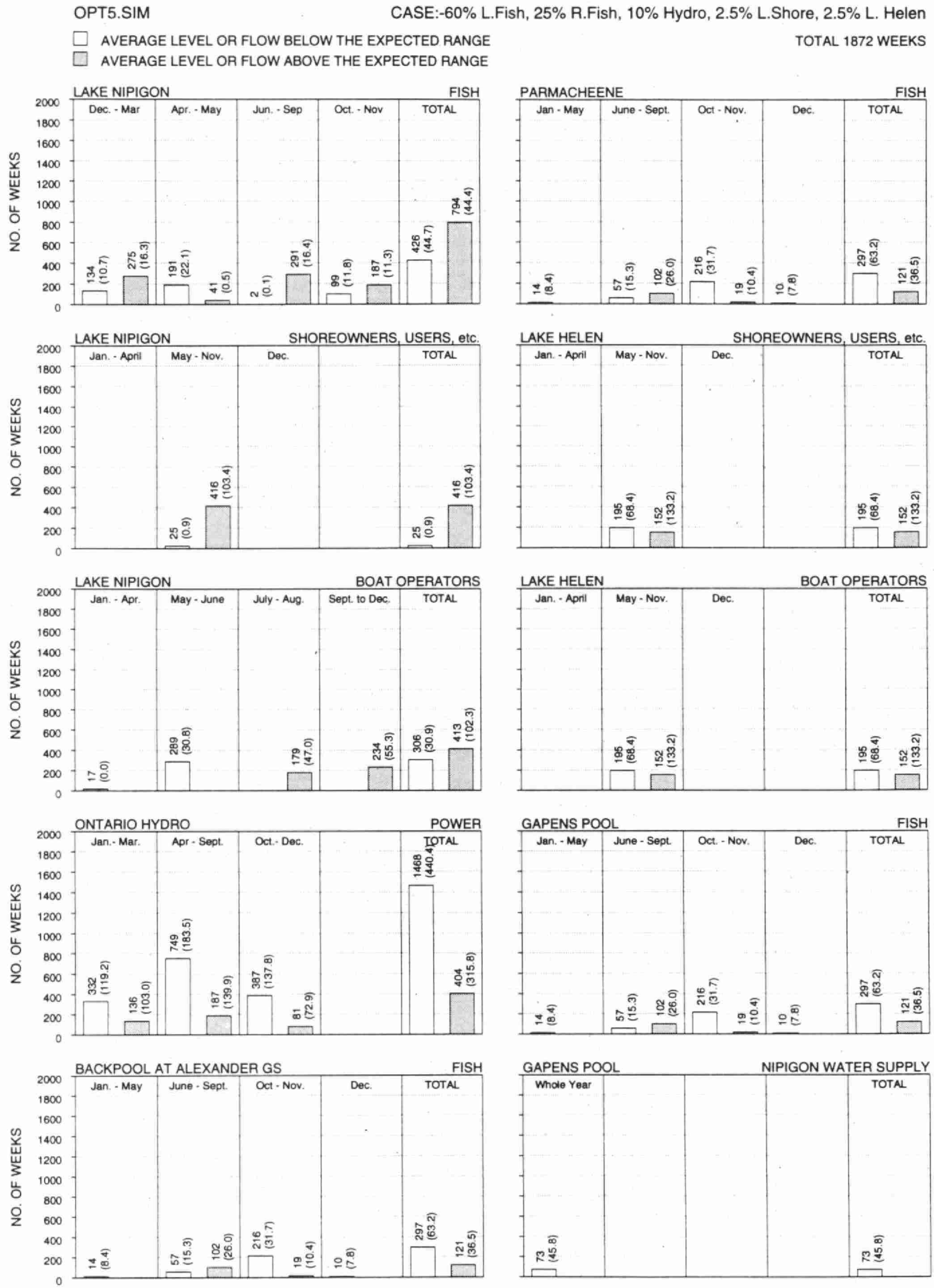


Figure 4.2 Penalty Values for Average Lake Levels and River Flows, Option OPT5

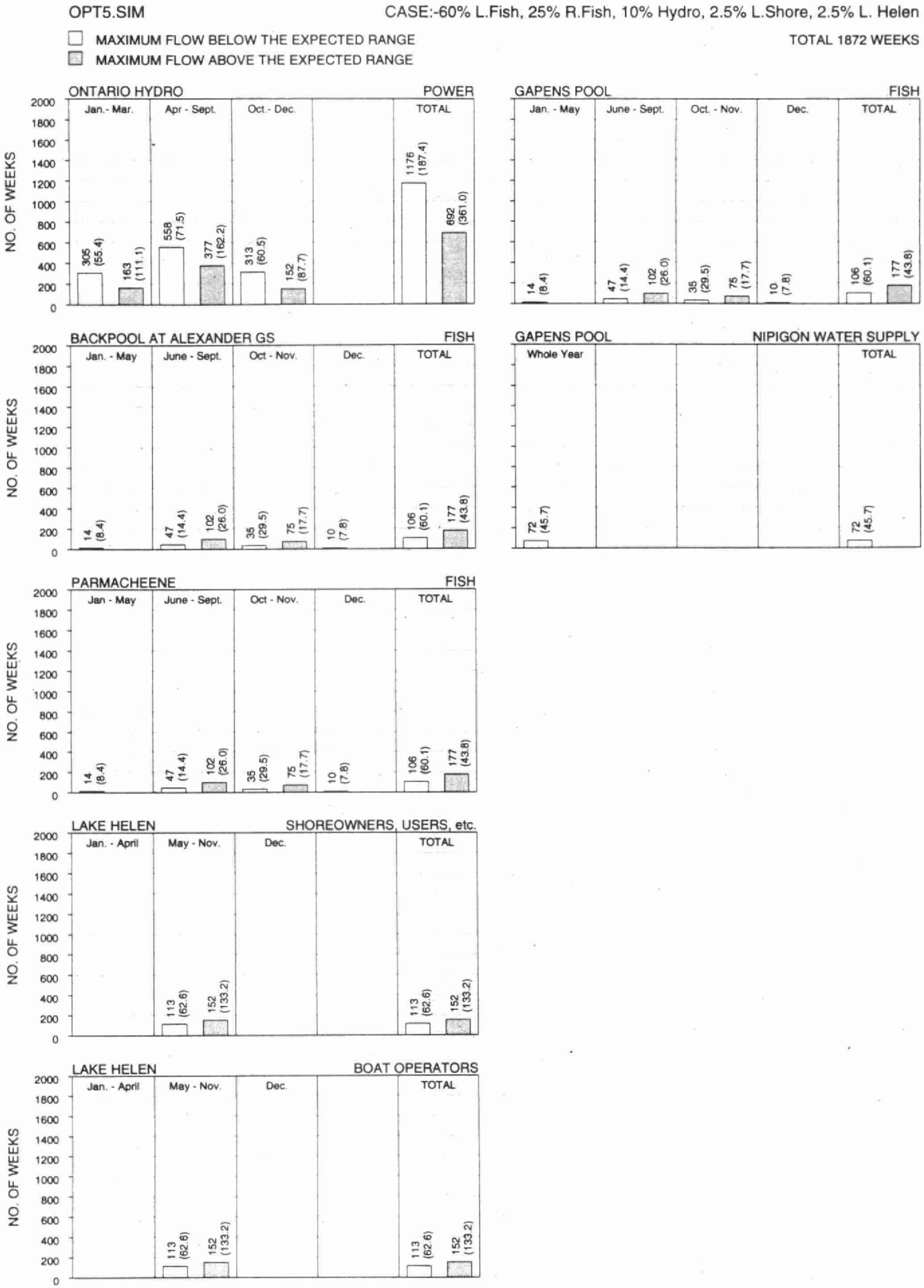


Figure 4.3 Penalty Values for Maximum River Flows, Option OPT5

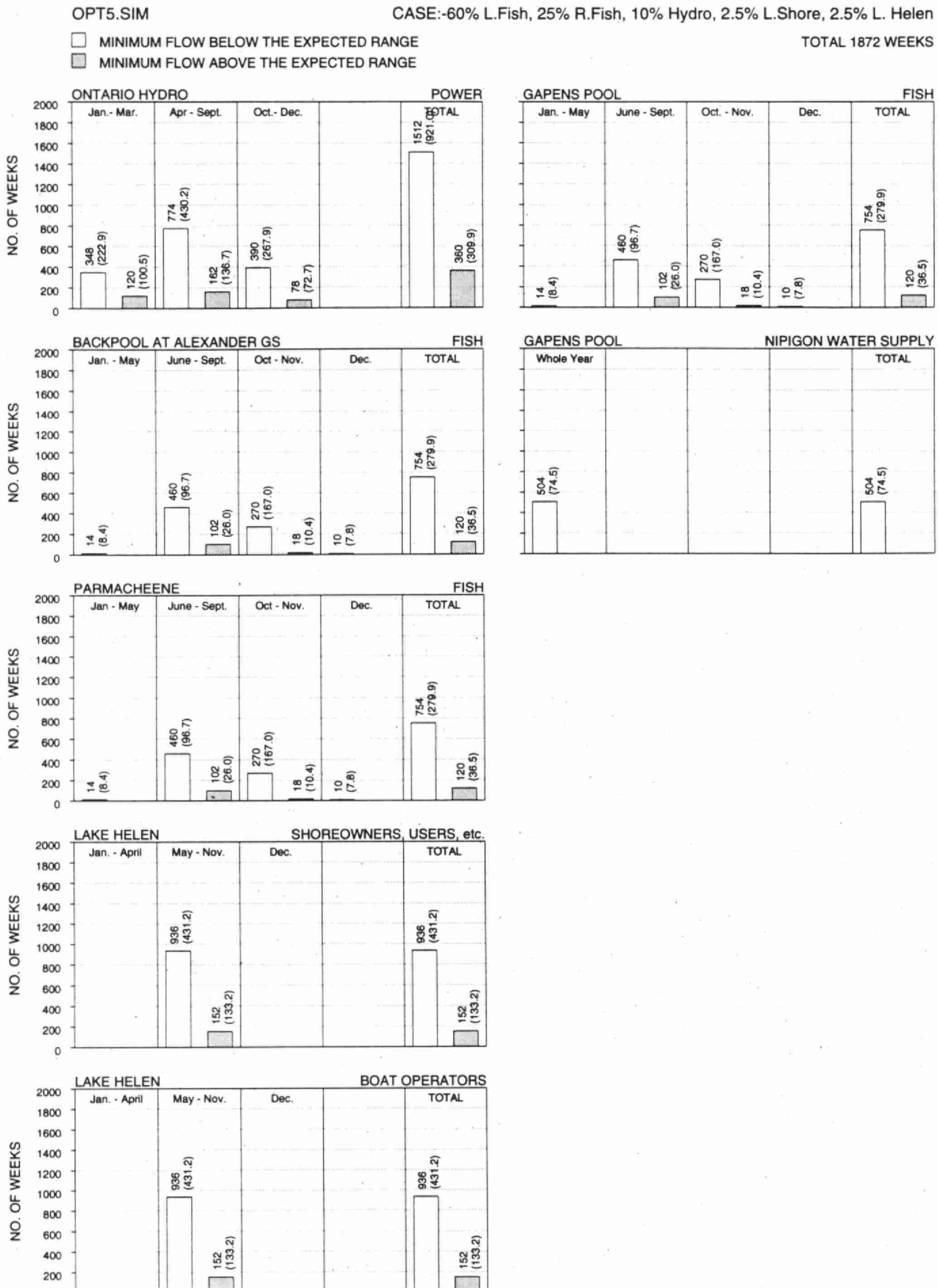


Figure 4.4 Penalty Values for Minimum River Flows, Option OPT5

As shown in Figures 4.2, 4.3 and 4.4, a separate set of bar graphs is provided for each of the eight stakeholders. The stakeholder and location are identified at the top right and left hand corners respectively of each of the eight graphs shown on each page. For example, in Figure 4.2, the graph at the top left-hand corner represents the results for "Lake Nipigon" (i.e., the location) "fish" (i.e., the stakeholder).

The bars in the graphs represent the number of weeks (up the left hand side of the graphs) that the weekly Lake Nipigon level or Nipigon River flow were above (shaded bar) or below (unshaded bar) the target or "expected range" for each given stakeholder during the period of the year indicated for that particular option. The total number of weeks for all periods of the year is also provided. The target level or flow is the level or flow at the "0.0" point on the penalty function (refer to Section 3.2.1). The number not in brackets, at the top of each bar, is the actual number of weeks represented by the bar. For example, in Figure 4.2, for Lake Nipigon fish (graph in upper left-hand corner of page), during the period April to May (second column of graph), the average weekly level of Lake Nipigon was below the target level (unshaded bar) for a total of 191 weeks and was above the target level (shaded bar) for 41 weeks. The totals for the year (last column in graph) that the flows were below and above the target was 426 weeks and 794 weeks respectively.

The number in the brackets at the top of each bar is the sum of all the weekly penalty values for the specified period of the year for the total simulation period (1951-86). For example, in Figure 4.4, for brook trout ("fish") at "Gapens Pool" (on the Nipigon River), during the period October to November (refer to the third column in the top graph on the right-hand side of the page), the total penalty for the minimum flow below the target is "167.0". The sum total, from January to December (last column of the graph), of the penalty values for the minimum flows below and above the target flow are 279.9 and 36.5 respectively (numbers in brackets).

The sum of all the weekly penalty values is an indication of how significant the penalty was for going above or below the target level or flow. The weekly penalty value is determined by taking the lake level or river flow for that week and then reading off the corresponding penalty on the appropriate penalty function. For example, say that in the third week of June, the minimum flow was 170 m^3/s. To determine the penalty value for, say brook trout at Alexander Backpool, one would look at the June to September penalty function in Figure 3.5 (second from top of page) and find 170 m^3/s on the vertical axis (left hand side) and see that the line intercepts the penalty value of 0.2. Therefore, the penalty value for that week, for the minimum flow of 170 m^3/s was 0.2. This procedure is repeated for every week of the simulation period and all the weekly penalty values are summed. The total number of weeks in the simulation period is 1,872 and is shown near the top right hand corner of the figures. The maximum sum of the penalty values possible for any stakeholder is 1,872 over the period from 1951 to 1986 (i.e., a penalty value of 1.0 for each of the 1,872 weeks in the period from 1951 to 1986).

It should be noted that the penalty functions only refer to the water quantity (i.e., lake water level and river flow conditions) interests of the stakeholders. The performance of the options relative to the penalty functions will provide an indication if the simulated Lake Nipigon level or Nipigon River flow conditions are closer to or further away from the desired conditions.

Comparison of Options - Lake Level/River Flow Conditions Relative to Historically Observed Data

Figure 4.5 provides a graphical comparison, for each option, of the change in the sum of the penalty values for selected factors above or below the desired level/flow, for the stakeholders, relative to the historically observed data (OBS 110). For hydro-electric power generation, the factor considered for comparison of the options is the estimated total dollar value of the power. The value of the power is discussed later in this Section.

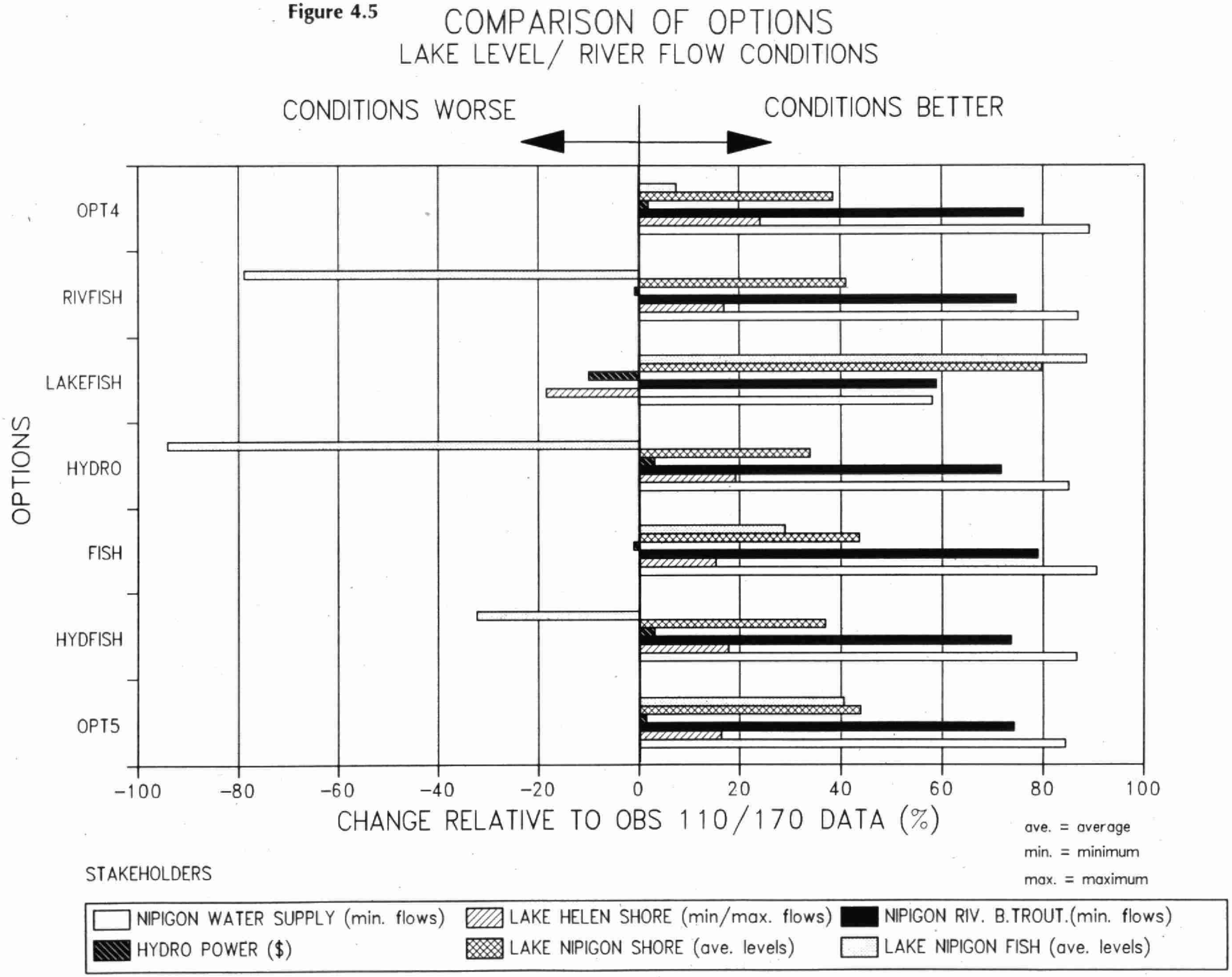
The difference between the option penalty values and the observed penalty values indicate if the water level or flow conditions would get better or worse. An increase in the penalty values means the conditions are getting worse and a decrease means that the conditions are getting better. The water level and flow conditions are a very important aspect of the fish habitat and spawning requirements. Improving the habitat and spawning conditions is an important factor in improving the overall health of the native Nipigon fisheries.

The graph in Figure 4.5 represents the difference between what happened from 1951 and 1986 and what would have happened if the simulated option had been in place. The benefits and drawbacks of each option can thus be seen. As an example, in Figure 4.5 one can see that river flow conditions for Nipigon River brook trout would have been much better (i.e., 75 percent) and lake level conditions for Lake Nipigon fish would have been worse (i.e., 78 percent) using the RIVFISH option when compared to what actually happened between 1951 and 1986. The reader is cautioned that the graph does not say that there would have been 75 percent more brook trout in the river and 78 percent less fish in the lake. It only says that level and flow conditions would have been better and worse respectively.

To simplify these comparisons some of the stakeholders have been considered together. Lake Helen and Polly Lake shoreline owners and users have been combined with Lake Helen/Nipigon River boaters because their penalty functions are the same. Therefore the results for one stakeholder will be the same as for the other stakeholder. The penalty functions for the three locations of brook trout on the river are also the same hence they are considered together as "Nipigon River brook trout". Considering the three locations as one does not provide the Nipigon brook trout with three times the weight. The results of Lake Nipigon boaters are very similar to Lake Nipigon shore owners and users for all the options and they can reasonably be considered together.

The minimum flows considered with the observed data (OBS 110) are only the potential minimum flows (as discussed in Section 3.6). That is to say, for the historically recorded average flow, there was a potential to peak the flows between the maximum and minimum values specified. However, Ontario Hydro did not necessarily follow that exact pattern of peaking. In some instances, Hydro may not have peaked the flows at all and in other instances, they may have used an even lower minimum flow. However, the difference between the OBS 110 data and the results of the other options provides a reasonable representation of the potential change in the lake level and river flow conditions.

Figure 4.5


COMPARISON OF OPTIONS
LAKE LEVEL/ RIVER FLOW CONDITIONS
CONDITIONS WORSE
CONDITIONS BETTER
OPT4
RIVFISH
LAKEFISH
HYDRO
FISH
HYDFISH
OPT5
OPTIONS
-100
-80
-60
-40
-20
0
20
40
60
80
100
CHANGE RELATIVE TO OBS 110/170 DATA (%)
ave. = average
min. = minimum
max. = maximum
STAKEHOLDERS
NIPIGON WATER SUPPLY (min. flows)
LAKE HELEN SHORE (min/max. flows)
NIPIGON RIV. B.TROUT.(min. flows)
HYDRO POWER ($)
LAKE NIPIGON SHORE (ave. levels)
LAKE NIPIGON FISH (ave. levels)

The selected factors chosen for comparison are those aspects of the lake level or river flow that are more important to the individual stakeholder. The factors used are as follows:

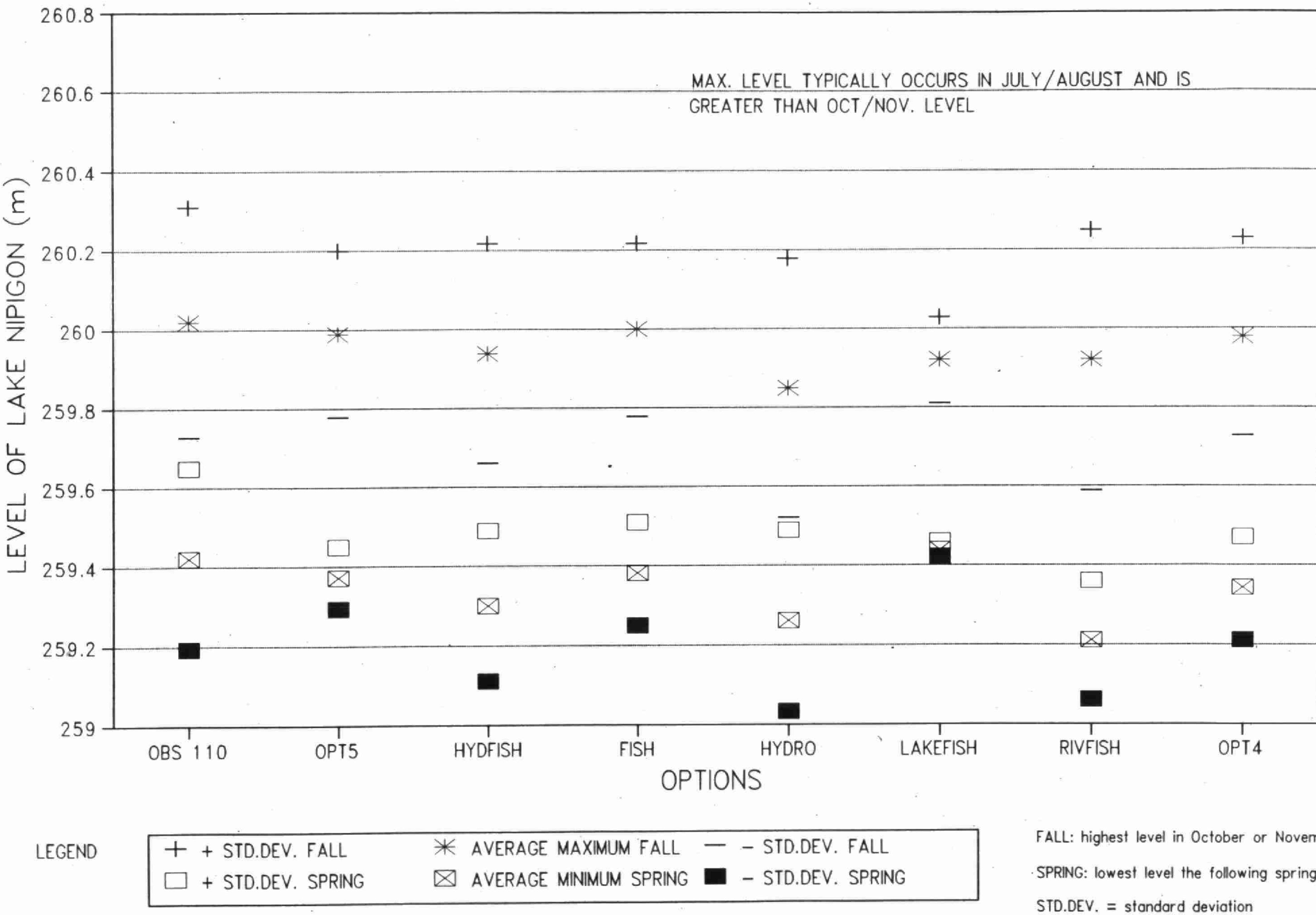
Stakeholder	Important Factor Selected for Consideration
Town of Nipigon/Red Rock Indian Band water supply	Penalty for minimum flow below target
Lake Helen shore owners/users & boaters	Penalty for minimum flow below target and maximum flow above target
Nipigon River brook trout	Penalty for minimum flow below target from October to May
Hydro-electric power	Total value of power ($)
Lake Nipigon shore owners/users	Penalty for average lake level above and below target
Lake Nipigon fish	Penalty for average lake level below target from October to May and above target from October to November

Lake Nipigon Levels in the Fall and the Spring

The averages of the maximum fall and minimum spring Lake Nipigon levels, for each of the options, are shown in Figure 4.6. The maximum fall level is considered to be the highest level the lake reaches in October or November. Typically, but not always, that occurs in the first week of October. The minimum spring level is the lowest level that the lake drops to the following spring. Also shown is the standard deviation value of the fall and spring levels. The standard deviation is a statistical value that indicates that 68 percent of the time, the value being considered (i.e., lake level) will be within plus or minus one standard deviation of the average value, assuming a normal distribution. For example, in Figure 4.6, one can see that the average maximum fall level for Option OPT5 is 259.99 m and that 68 percent of the time the maximum fall level will be between 260.20 m and 259.78 m (plus and minus one standard deviation). Standard deviation is a measure of the variability of the value being considered. The smaller the standard deviation value, the less variable the value. The complete data on the maximum fall levels and minimum spring levels, including average, standard deviation, maximum and minimum, for each of the options, are provided in Appendix F.

Figure 4.6 COMPARISON OF OPTIONS

LAKE NIPIGON LEVELS (FALL & SPRING)



FALL: highest level in October or November

SPRING: lowest level the following spring

STD.DEV. = standard deviation

Lake Nipigon Fall to Spring Drawdown

The average maximum fall to minimum spring drawdown values for each of the options, along with the standard deviation, are presented in Figure 4.7. The fall to spring drawdown is the drop in the Lake Nipigon water level from the maximum level in October and November to the lowest level the following spring.

Appendix F provides a more detailed set of data on the Lake Nipigon fall to spring drawdown including the yearly values, and the average, standard deviation, maximum and minimum values. The yearly drawdown values (column 9) are provided in Appendix F (numbered "FROM: [year] 0" (columns 1 and 2)... "TO: [year] 1" (columns 5 and 6)) along with the actual October/November maximum (column 4) and spring minimum (column 8) levels (in metres) and the week of the year in which the maximum/minimum levels occurred (columns 3 and 7 respectively).

It should be noted that the fall to spring drawdown is not the total yearly drawdown. The level of the lake typically is at its greatest in July or August. Therefore the total yearly drawdown will be greater than the fall to spring drawdown.

Value of the Hydro-Electric Power

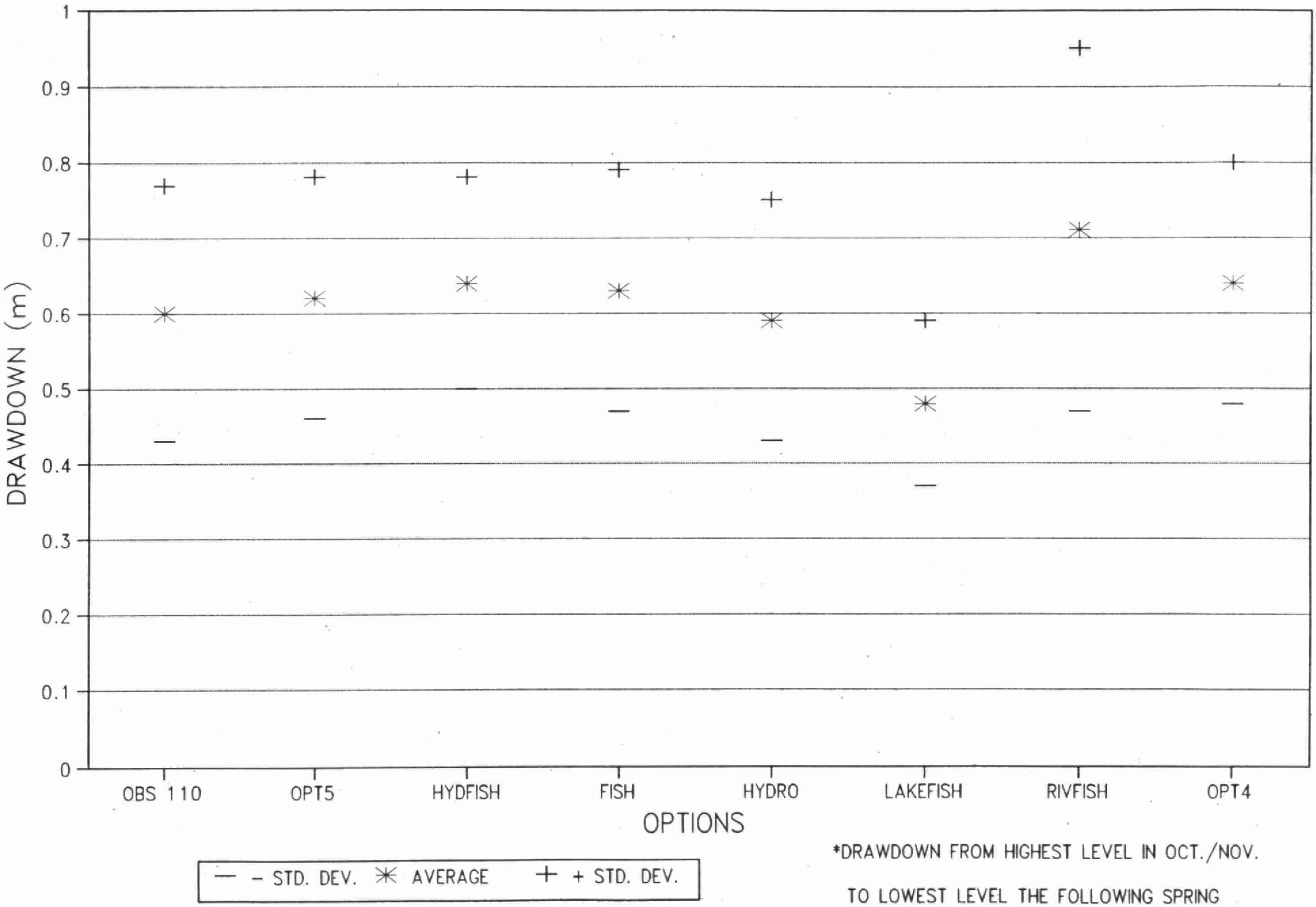
Over the course of a year, the value to Ontario Hydro of the energy produced at Nipigon varies. Energy has more value during the peak electricity demand periods than during the off-peak periods. The value to Ontario Hydro of the hydro-electric power generated by the three Nipigon generating stations was estimated for each of the options. Figure 4.8 shows the estimated average annual off-, on-peak and total values for the options. The off-peak value is from midnight to 7:00 a.m. and the on-peak value is from 7:00 a.m. to midnight. The total is the sum of the off- and on-peak values.

The values were estimated on a weekly basis for the entire simulation period from 1951 to 1986. The conversion factors from flow (m^3/s) to megawatts (Mw) were 0.616 $Mw/m^3/s$ for river flows less than or equal to 400 m^3/s and 0.555 $Mw/m^3/s$ for flows greater than 400 m^3/s (B. Vinski, Ontario Hydro, pers. comm., February 24, 1994). Composite weekly on-peak and off-peak marginal costs for each month were derived from the information in the *Draft Options Report* (Atria, 1993). The composite weekly values used are provided in Table 4.1

The marginal costs are directly affected by such factors as energy demand, equipment and weather and can change. Current Ontario Hydro forecasts of annual energy values (B. Vinski, Ontario Hydro, pers. comm., February 24, 1994) are actually less than the annual averages of the costs used in this study.

More detailed information on the estimated value of the energy for each of the options is provided in Appendix F including on-peak, off-peak and total values of Mwh's (megawatt-hours) and dollars for every year, for the total period (1951 to 1986). The average annual values are also provided. Additional information is provided for the first half of 1977 and the combined last half of 1981 and the first half of 1982.

Figure 4.7 COMPARISON OF OPTIONS
LAKE NIPIGON FALL/SPRING DRAWDOWN



*DRAWDOWN FROM HIGHEST LEVEL IN OCT./NOV.
TO LOWEST LEVEL THE FOLLOWING SPRING

Figure 4.8 COMPARISON OF OPTIONS
VALUE OF HYDRO-ELECTRIC POWER

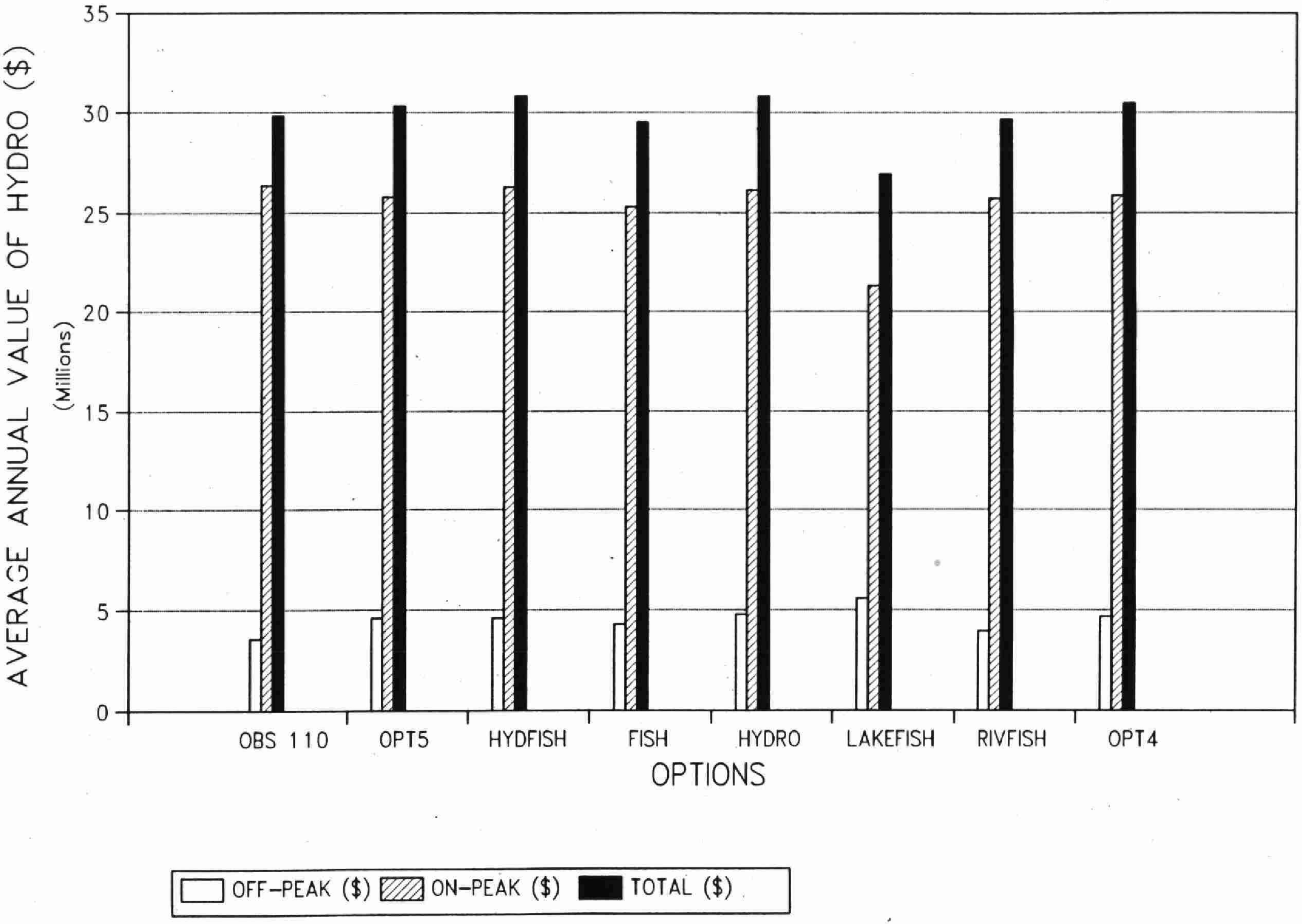


Table 4.1 Monthly Composite Marginal Costs

Month	On-peak ($/Mwh)	Off-peak ($/Mwh)
Jan.	21.7	17.0
Feb.	23.6	17.4
Mar.	21.9	17.2
Apr.	16.3	10.3
May	15.3	7.8
Jun.	14.5	7.5
Jul.	15.3	8.8
Aug.	19.6	12.6
Sep.	17.9	9.8
Oct.	16.3	11.3
Nov.	18.3	13.3
Dec.	18.1	15.5

Appendix F also provides summary data on the potential for Ontario Hydro to carry out peaking of the generating stations with each of the options. The number of weeks where peaking is or is not possible, based on the average flows, is presented. Statistics are provided on the number of weeks where peaking greater than 100 m^3/s, greater than 200 m^3/s and greater than 300 m^3/s is possible. Peaking is the difference between the maximum flow and the minimum flow. These statistics represent the potential for peaking. Hydro's actual need to peak the stations is dependant on the overall power requirements.

4.2 EVALUATION OF THE OPTIONS

A description of the results of the simulation of the options (presented in Section 4.1) is provided in the following sub-sections.

Option OBS 110

The average Lake Nipigon water level dropped below the October to May target levels for the fish a total of 316 weeks (25.1 percent) out of a possible total of 1,260 weeks over the simulation period from 1951 to 1986. The sum of the total penalty was 79.9. During the fall spawning period of October and November, the water level was above the target level for 207 weeks (71.9 percent) out of a possible total of 288 weeks.

The Lake Nipigon level was infrequently (56 weeks out of total 1080, or 5 percent of the time) below the shore owners and users target level of 259.4 m (851′). The level was above the target level of 260 m (853′) 46.6 percent of the time (503 weeks). The total penalty for levels above and below the target was 186.2.

The average maximum weekly level of Lake Nipigon in October and November was 260.02 m (853.13′) with a standard deviation of 0.29 m. The maximum yearly level is higher and occurs earlier (typically July or August). The average minimum spring level was 259.42 m (851.16′) with a standard deviation of 0.23 m. The levels are shown in Figure 4.6. As discussed in Section 4.1, Appendix F provides the annual maximum (October/November) and minimum levels.

The observed average annual October to spring drawdown is 0.60 m (1.97′) with a standard deviation of 0.17 m. This means that about 7 out 10 times the drawdown was between 0.43 m (1.41′) to 0.77 m (2.53′).

For brook trout on the Nipigon River (at Backpool, Parmacheene and Gapens Pool), the minimum flow potentially dropped below the target values during the critical spawning, incubation and hatching period (October to May) for a total of 853 weeks (67.7 percent) out the possible total of 1260 weeks over the simulation period from 1951 to 1986. The sum of the penalty below the target flow for this same October to May period was 709.7. If the minimum flow restriction in the winter (October to May) was increased from 110 m^3/s to 270 m^3/s, when possible, (while maintaining the same average flows), the number of weeks when the flow was below the target value would decrease substantially to 373 weeks. The total penalty for the Nipigon River brook trout would be reduced to 191.0 from 709.7. A reduction in the penalty value means an improvement in the conditions. From this it is evident that the minimum flow restriction on its own would reduce the number of times that brook trout redds on the river were exposed. There would be no effect on the Lake Nipigon levels because the average flows would not be altered. This is not necessarily the case with the interim flow agreement which sets the minimum flow at 270 m^3/s and thus results in different average weekly flows.

The average annual value of the power for option OBS 110 was $29,874,000 (see Table 4.2 and Figure 4.8). The average annual value would be reduced by $347,000.00 (1.2 percent) if the flow restriction of 270 m^3/s in the winter was in place (and assuming that the average flow values were maintained). This demonstrates a important point for comparing alternatives. If the average weekly lake levels are the same for two alternatives, then the average weekly river flows must be the same (assuming the same inflow for both). Now, if one of these alternatives has a higher minimum flow requirement (i.e., more restrictive), it will produce less value of hydro-electric power. However, if two different alternatives are not required to have the same weekly lake elevations, the alternative with the higher minimum flow restriction will not necessarily provide the least hydro value.

The *Draft Options Report* (Atria, 1993, refer to Table 4.3.2), provided an estimate of the replacement cost due to flow restrictions. As a point of clarification, that estimate was based only on the replacement cost of the lost on-peak value. However, the on-peak loss should have been offset by gains made during the off-peak period. Therefore, the resultant loss in the 1993 report should have been reported as $450,000.00 per year.

Table 4.2 Simulated Average Annual Value of Hydro-Electric Power

Option	Average Annual Value of Hydro Power ($)	Difference in Average Annual Value from OBS 110 ($)	Comments
OBS 110	29,873,839	n/a	Additional restriction on winter minimum flow (from 110 m^3/s to 270 m^3/s) while maintaining the same Lake Nipigon water levels reduces value of power by $346,522.
RIVFISH	29,686,810	-187,029	
LAKEFISH	26,927,553	-2,946,286	
HYDRO	30,855,177	+981,338	Allowing minimum flow down to 70 m^3/s year-round, while maintaining average flow determined by HYDRO option, would provide an additional value of $182,000.
FISH	29,544,004	-329,835	
HYDFISH	30,822,970	+949,131	
OPT4	30,520,669	+646,830	
OPT5	30,365,374	+491,535	Allowing minimum flow down to 70 m^3/s year-round, while maintaining average flow determined by OPT5 option, would provide an additional value of $361,000.

For Lake Helen and Polly Lake shore owners and users, including boaters, the number of weeks when the maximum flows were above or the minimum flows were below the target values for May to November were 136 and 817 weeks respectively. Combined these represent 88.2 percent of the total possible weeks from 1951 to 1986 and have a total penalty of 677.

The minimum river flow was potentially below the Town of Nipigon/Red Rock Indian Band water supply target value of 180 m^3/s 1,000 weeks (54.3 percent) of the total 1,872 weeks from 1951 to 1986.

Option RIVFISH

With Option RIVFISH there is a significant improvement in the weekly flow conditions for Nipigon River brook trout. This could be expected due to the 100 percent weighting given to the river brook trout and the minimum flow restriction of 270 m^3/s from May to October. The sum of the penalty below the target flow improves by 75.0 percent compared to the observed data (see Figure 4.5). Water level conditions for fish on Lake Nipigon would be 79 percent worse according to the penalty values. As seen in Figure 4.7, the average drawdown of the lake increases to 0.71 m (2.33′). The variability of the drawdown also increases. Hydro-electric power values would decrease slightly (less than 1 percent). The rest of the stakeholders would experience improved water level and flow conditions.

Option LAKEFISH

From Figure 4.5 one can see that Option LAKEFISH results in improved water level conditions for the fish and shore owners/users on Lake Nipigon. The penalty values for fish and owners/users improve by 89 percent and 80 percent respectively over the observed situation. The average maximum level in the fall is lower and the minimum level in the spring is higher than the historically recorded levels (see Figure 4.6). As well, the variability is reduced, especially in the spring. The resulting fall to spring drawdown (see Figure 4.7) is decreased from 0.60 m (1.97′) to 0.48 m (1.57′).

River flow conditions for Nipigon River brook trout and the Nipigon water supply improve 59 percent and 58 percent respectively. Much of this improvement for these two stakeholders can be attributed to the minimum flow restriction.

Hydro-electric power value decreases and Lake Helen/Nipigon River shore owners and users experience worse conditions.

Option HYDRO

The Option HYDRO, with a minimum flow restriction of 270 m^3/s from October to May, and 170 m^3/s from June to September, provides a slight increase (3.3 percent) increase in the value of the power generated (see Figure 4.5). The average annual value of the power is estimated to be $30,855,000 (see Table 4.2 and Figure 4.8). All other stakeholders see an improvement in water level and flow conditions except fish on Lake Nipigon. The minimum flow restrictions tend to keep the river flow conditions suitable for the river stakeholders.

Water level conditions for Lake Nipigon fish are estimated to get 94 percent worse (see Figure 4.5). The fall level is lower than the OBS 110 level but the spring level is also significantly lower (see Figure 4.6). The variability of the spring level remains the same.
With Option HYDRO, the simulated weekly levels of Lake Nipigon did not exceed Ontario Hydro's present absolute upper limit of 260.6 m (855').

As part of the computer modelling analysis, the Study Team examined two other minimum flow restriction scenarios for the HYDRO option: 70 m^3/s throughout the year; and 110 m^3/s in the winter and 170 m^3/s in the summer. For the purpose of this discussion, these additional two scenarios are referred to as HYDRO(1) and HYDRO(2) respectively. The scenario which was used in this study (i.e., minimum flow restriction of 270 m^3/s from October to May, and 170 m^3/s from June to September) is referred to here as HYDRO(3).

These three scenarios are really three different options resulting in different weekly river flows and lake levels. HYDRO(3) provided more dollar value of power than the other two scenarios over the 36 year period of simulation because the reduced value during on-peak periods was more than offset by the increased off-peak period values (i.e., more flow at lower unit cost was greater overall than less flow at higher unit cost). HYDRO(3) provided the worst water level conditions for the Lake Nipigon fish (generally because the water levels were lower) but the best flows for the Nipigon River brook trout. HYDRO(1) provided less power value than HYDRO(3). HYDRO(1) resulted in the most suitable conditions for Lake Nipigon fish (higher water levels) but the worst for Nipigon River brook trout.

The reader is reminded, as discussed in Option OBS previously, that higher minimum flow requirements (i.e., 270 m^3/s versus 110 m^3/s) will result in a lower power value for a given lake level. However, if the level of the lake is not constrained or given (as is the case with HYDRO(1), HYDRO(2) and HYDRO(3)), then higher minimum flow conditions do not necessarily result in lower power values.

A comparison between HYDRO(3) and HYDRO(2) is provided in Appendix G. With a minimum flow restriction of 110 m^3/s in the winter, the net effect of HYDRO(2) on Lake Nipigon is to provide spring levels which are higher than HYDRO(3). This results in better water level conditions for Lake Nipigon fish. However, all other stakeholders experience worse conditions with HYDRO(2).

Ontario Hydro could increase the output (and hence the value of power) from Option HYDRO(3) (i.e., minimum flow restriction of 270 m^3/s/170 m^3/s), without changing the average flow conditions, by being allowed to reduce the flow down to 70 m^3/s year-round during off-peak demand periods. A minimum flow restriction of 70 m^3/s (on an hourly basis) is consistent with Hydro's operating directive prior to the interim flow agreement. By reducing the flow during the off-peak demand period, Ontario Hydro could increase the flow during the on-peak period while still maintaining the daily average flow at the value determined by the option. This approach would be particulary advantageous to Ontario Hydro during periods of low water inflow. The increase in the average annual value of the power, over the entire 36 year simulation period, was estimated to be \$182,000.00 per year (a 0.6% increase) based on minimum flow of 70 m^3/s (see Table 4.2). However, decreasing the minimum flow down to 70 m^3/s would result in a significant negative impact to other stakeholders, particularly the Nipigon River brook trout. Based on a comparison

of the total penalty values of OBS 110, HYDRO(1) and HYDRO(3), the water flow conditions for the river brook trout, for HYDRO(1), with the 70 m^3/s minimum flow restriction, would be worse than the observed conditions and would be almost 4 times worse than the HYDRO(3) option with the 270/170 m^3/s restriction. If the minimum flow restriction was 110 m^3/s in the winter and 170 m^3/s in the summer (as was the situation prior to the interim flow agreement), the average increase in value would be less than $182,000. per year but the penalty to the Nipigon River brook trout would still be almost 4 times worse. This is because the maximum penalty of 1.0 is for a flow of 113 m^3/s. In addition, the penalty would be worse than the observed conditions.

Option FISH

Option FISH improves water level and flow conditions for all of the stakeholders except hydro-electric power generation (see Figure 4.5). Improvements for Lake Nipigon fish, Lake Nipigon shore owners and users, Nipigon River brook trout, Lake Helen/Nipigon River shore owners and users and Nipigon/Red Rock Indian Band are 29, 44, 79, 16 and 91 percent respectively. The value of the power decreases by 1 percent.

The average maximum level of Lake Nipigon in the fall decreases only slightly (2 cm). The variability also decreases. The average spring level decreases 4 cm (1.6 inches) but the variability also decreases to a greater extent thereby making the overall spring conditions better (see Figure 4.6). The fall to spring drawdown is 0.63 m (2.07').

Option HYDFISH

Option HYDFISH improves water level and flow conditions for all of the stakeholders except Lake Nipigon fish (see Figure 4.5). Lake Nipigon fish water level conditions get 32 percent worse than the observed conditions. The average maximum level of Lake Nipigon in the fall is 8 cm lower than the observed level but the variability remains very similar (see Figure 4.6). The average spring level decreases 12 cm (4.7 inches). The variability improves slightly.

In an attempt to improve the conditions for the Lake Nipigon fish, the Study Team examined a revised version of Option HYDFISH. A minimum flow restriction of 190 m^3/s from October to May was used (HYDFISH 190). The result was that conditions were still worse (4 percent) than OBS 110 for Lake Nipigon fish but they did improve over HYDFISH 270 (which was 32 percent worse than OBS 110) (see Appendix G). As could be expected, lowering the minimum flow restriction results in a decrease in the flow conditions for brook trout on the Nipigon River (from 74 to 13 percent).

Options OPT4 and OPT5

Options OPT4 and OPT5 provide similar results (see Figure 4.5). Both improve conditions for the all the stakeholders. All the improvements, except one, are similar and are as follows:

Stakeholder	Improvements OPT4	Improvements OPT5
• Lake Nipigon shore users	39%	44%
• Lake Nipigon boaters	27%	33%
• Hydro power	2.2%	1.7%
• Nipigon River brook trout	76%	74%
• Lake Helen shore users/boaters	24%	17%
• Town of Nipigon/Red Rock Indian Band water supply	89%	85%

The significant difference is that OPT4 improves Lake Nipigon fish water level conditions only 7.7 percent while OPT5 improves the conditions 41 percent. This is because OPT5 has a greater weighting factor on Lake Nipigon stakeholders compared to Nipigon River stakeholders.

The fall Lake Nipigon levels for OPT4 and OPT5 are very similar (i.e., only 1 cm difference) and are slight improvements over the observed fall level (see Figure 4.6). The variability of the OPT5 fall level is better than OPT4. The spring level for OPT5 is 3 cm higher than OPT4 and OPT5 levels are less variable thus making OPT5 better for Lake Nipigon fish.

The higher weighting of the lake interests in OPT5 provides a greater degree of protection to the lake fish (i.e., lower total penalty value) and lesser protection (i.e., higher total penalty value) for the river fish than OPT4 at times of low water inflow (i.e., very dry years). The difference in the number of weeks and the total penalty value when the lake levels and river flows would have been below the target range during the simulation period from 1951 to 1986 is summarized as follows from the information in Appendix F:

Stakeholder Concern	**No. of Weeks**		**Total Penalty**	
	OPT4	OPT5	OPT4	OPT5
Lake Nipigon level below lake fish target level (October to May)	479	424	75.4	44.6
Nipigon River minimum flow below brook trout target flow (October to May)	296	294	167.8	183.2

The Study Team examined how OPT4 could be adjusted to improve water level conditions for Lake Nipigon fish by lowering the minimum flow restriction from 270 m^3/s to 230 m^3/s. The lake fish conditions would change from an improvement of 7.7 percent to an improvement of 10.6 percent (see Appendix G). There would be an accompanying decrease in improvements for Nipigon River brook trout from 76 percent to 45 percent and for Lake Helen/Nipigon River shore owners and users from 24 percent to 12 percent.

OPT5 provides an average annual value of power of $30,365,000.00 (see Table 4.2 and Figure 4.8). As was done with Option HYDRO, the Study Team looked at how Ontario Hydro could increase the output (and hence the value of power) from Option OPT5 (with minimum flow restriction of 270 $m^3/s/170$ m^3/s), without changing the average flow conditions that were simulated. This was done by allowing Hydro to reduce the flow down to 70 m^3/s during off-peak demand periods and to increase flow accordingly during the on-peak demand period. As was noted earlier, a minimum flow restriction of 70 m^3/s (on an hourly basis) is consistent with Hydro's operating directive prior to the interim flow agreement. Using a year-round minimum flow of 70 m^3/s, the increase in the average annual value of the power, over the entire 36 year simulation period, was estimated to be $361,000.00 per year (a 1.2% increase) (see Table 4.2). However, decreasing the minimum flow down to 70 m^3/s would result in a significant negative impact to other stakeholders, particularly the Nipigon River brook trout. It was estimated in the Option HYDRO discussion earlier, that the water flow conditions for the river brook trout, with the 70 m^3/s minimum flow restriction, would be almost 4 times worse than the situation with the 270/170 m^3/s restriction and would be worse than the existing conditions (OBS 110). If the minimum flow restriction was 110 m^3/s in the winter and 170 m^3/s in the summer (as was the situation prior to the interim flow agreement), the average increase in value would be less than $361,000. per year but the penalty to the Nipigon River brook trout would still increase by 3 to 4 times.

4.3 INITIAL COMPARISON

One should remember that these options are simulations and that they are not exact predictions of what will happen. However, they do provide a good indication of the relative impacts of the options based on the best available data.

The following key points are evident from an initial comparison of the optimization and simulation results:

- Increasing the minimum flow restriction from 110 m^3/s to 270 m^3/s, during the months of October to May, significantly improves flow conditions for stakeholders on the river, especially the brook trout.
- With a minimum flow restriction of 270 m^3/s from October to May, higher weighting factors are necessary for Lake Nipigon stakeholders, relative to the river stakeholders (see options LAKEFISH, OPT5, FISH AND OPT4) in order to keep Lake Nipigon water levels as close as possible to the desired conditions for fish in the lake.

- Comparing the results of different minimum flow restrictions (Appendix G) suggests that decreasing the winter minimum flow restriction may improve the Lake Nipigon water level conditions for fish but not without a significant accompanying decrease in the suitability of the Nipigon River flow conditions for the brook trout.

- Figure 4.5 shows that options with weighting factors ranging from 25 percent to 100 percent for the Nipigon River brook trout, along with a minimum winter flow restriction of 270 m^3/s, resulted in relatively similar improvements to the minimum flow conditions for the river brook trout. For these options, the improvements varied from 72 to 79 percent. The lower weighting factor of 25 percent for river brook trout was accompanied by weighting factors for other Nipigon River stakeholders.

  LAKEFISH is the only option with a significantly different result for the Nipigon River brook trout flow conditions (59 percent improvement, see Figure 4.5). LAKEFISH had a weighting factor of zero assigned to river brook trout but it included a minimum flow restriction of 270 m^3/s in the winter.

- From Figure 4.5, comparison of the options relative to the total penalty of flows and levels above and below the target values, it appears that Options RIVFISH, LAKEFISH, HYDRO and HYDFISH may be the least desirable. RIVFISH, HYDRO and HYDFISH result in significantly worse water level conditions for Lake Nipigon fish. RIVFISH also reduces the value of the power slightly. Option LAKEFISH makes the flow conditions worse for Lake Helen/Nipigon River shore owners and users and boaters and also reduces the value of the power.

  The remaining options, FISH, OPT4 and OPT5, perform in a similar manner for the all the stakeholders, except OPT5 which is significantly better than FISH for Lake Nipigon fish. FISH is better for Lake Nipigon fish than OPT4. FISH also results in a relatively small (in terms of percentage of value of power) decrease in the value of the hydro-electric power.

- All the options, except RIVFISH and HYDRO, improve the Lake Nipigon fall maximum water level conditions by a combination of lower averages and reduced variability (see Figure 4.6).

- All the options, except LAKEFISH, lower the average minimum spring (April and May) water level (see Figure 4.6). However, the reduced variability of the spring water levels with Options FISH and OPT5 offsets these lower average levels resulting in better overall spring conditions with FISH and OPT5.

- The average fall to spring drawdown of Lake Nipigon (see Figure 4.7) for Options OPT5 and HYDRO are similar (maximum difference 2 cm (0.8 inches)) in magnitude to the observed value of 60 cm (23.6 inches) (OBS 110). The variability is slightly reduced. Option LAKEFISH reduces the fall/spring drawdown from 60 cm to 48 cm (18.9 inches) and also reduces the variability. Option FISH and OPT4 increase the drawdown by 3 cm (1.2 inches) and 4 cm (1.6 inches) respectively. RIVFISH increases the drawdown by 11 cm (4.3 inches) and the variability is also significantly increased.

- Greater consistency in the lake levels (i.e., reduced variability) is achieved by many of the options. This can be seen in the time series plots of the simulated lake levels for options LAKEFISH, FISH, HYDFISH, OPT4 AND OPT5 (see Appendix F). The lake does not go up as high or down as low as the observed data during wet and dry times respectively (i.e., see Figure 4.1, Option OPT5; years 1974 and 1977).

- Figure 4.8 and Table 4.2 show that the average annual value of the power generated by the options varies from \$29.54 million to \$30.86 million.

- Permitting Hydro to drop the minimum river flow to 70 m^3/s (on an hourly basis during the off-peak demand period, midnight to 7:00 a.m.) would increase the average annual value of the power for Options HYDRO and OPT5 by \$182,000 (0.6 percent) and \$361,000 (1.2 percent) respectively. The increased value of power would be accompanied by a significant decrease in the suitability of the flow conditions for the river brook trout (3 to 4 times less suitable) as well as other river stakeholders.

- All the option simulations used the historic net basin supply which includes the water from the Ogoki diversion. No change was made to the pattern or volume of inflow from the Ogoki. Therefore, all the options resulted in the same total volume of water being available to generating stations downstream of Nipigon (i.e., at Niagara and the St. Lawrence River). There would be no change in the amount of power that the downstream stations could produce.

- The options provide conditions which are, on average, better or worse than desired by the various stakeholders. There will still be times when the lake levels or river flows will be higher or lower than desired due to the large role played by the natural inflow conditions.

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APPENDICES

NIPIGON RIVER:

DEVELOPMENT OF A WATER MANAGEMENT PLAN

OPTIONS REPORT

April 1994

APPENDICES

A - Public Consultation - Summary Report to June 1993

B - Terms of Reference - Nipigon River Water Quantity Management Working Group

C - *UPDATE* newsletter, January 27, 1994
- Notice of Working Group Meetings Sent to Local Media
- News Release (October 13, 1993)
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D - MNR and Ontario Hydro Correspondence - Re: Brook Trout Redd Dewatering Under Winter Conditions

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Appendix A

Public Consultation
Summary Report to June 1993

NIPIGON RIVER
DEVELOPMENT OF A WATER MANAGEMENT PLAN

PUBLIC CONSULTATION - SUMMARY REPORT TO JUNE 1993

BACKGROUND

The Draft Options Report for the Development of a Water Management Plan for the Nipigon River was released to the public in May, 1993, at the completion of the first year of the two year study. The report outlined the public consultation effort that had been undertaken up to that point including interviews, mailings of "Update" newsletters, an article in the Nipigon Bay RAP and advertising for public meetings. During the second year, the public is being asked to review the draft options. Then costed options will be presented to the people and a consensus sought on a preferred option and implementation process.

In order to present the draft options to the public, a series of meetings were held in June 1993. This report summarizes the public meetings and provides documentation of feedback received from the people.

DISTRIBUTION OF REPORT

The Draft Options Report was mailed out to all the stakeholders who had been interviewed or had attended group meetings as well as any other individuals or groups who had expressed an interest in the study. Prior to the June public meetings, approximately 80 reports had been released. Subsequently an additional 15 reports have been sent out.

PUBLIC NOTIFICATION

People were notified of the public meetings by the following methods:

- An "Update" newsletter was sent to all the people on the study team's mailing list about two weeks prior to the release of the Draft Options Report. The Update advised them to expect the report in the mail shortly. It also outlined that public meetings were going to be held in Nipigon, Thunder Bay and Beardmore. Times and dates were provided along with the name and telephone number (call collect) of the Study Team's project manger.

- Advertisements announcing the public meetings were placed in the Nipigon and Thunder Bay newspapers, as well as The Lake Nipigon District Booster. A copy of the advertisement was included as a separate insert with the mailing of the report. Notices were posted in Nipigon and Beardmore.

- Media contact resulted in articles in the Chronicle-Journal/Times-News, the Times-News and the Lake Nipigon District Booster interviews on CJLB and CBQ radio, and Thunder Bay Television News.

PUBLIC MEETINGS

The public meetings were held as follows:

Tuesday, June 8
Royal Canadian Legion Hall
Nipigon

3-5 p.m. Drop In - Informal Discussion
7-10 p.m. Presentation and Discussion

Wednesday, June 9
New Government Building, Auditorium A
189 Red River Road
Thunder Bay

3-5 p.m. Drop In - Informal Discussion
7-10 p.m. Presentation and Discussion

Thursday, June 10
Evergreen Senior Citizens Club
Beardmore

3-5 p.m. Drop In - Informal Discussion
7-10 p.m. Presentation and Discussion

Displays, photographs, and maps were available at the public meetings and members of the Study Team were available to answer questions. In total, approximately 65 individuals attended the three public meetings. A breakdown of the recorded attendance is as follows:

	Afternoon Drop In	Evening Meeting	Total
Nipigon	8	18	26
Thunder Bay	11	14	25
Beardmore	3	15	18
			69

A few people attended both the afternoon and evening meetings.

At the evening presentation, the Study Team outlined the Draft Options Report by providing the background of the study and the data collection and interview process. The Team identified the users and summarized the conflicts. A brief outline of the fisheries concerns, especially with respect to the brook trout on the lower river, was given. The five preliminary options were presented for discussion.

Concerns expressed by the people who attended the public meetings were varied and related to such matters as:

- What is the importance of the Nipigon generators to Ontario Hydro total capacity?
- Can the Ogoki Diversion be considered in the options?
- Define the limits of the flows and levels and stick to them.
- The real problem is fluctuating levels on the river.
- Anglers have not caused the problem.
- What royalties does Ontario Hydro pay to the province?
- Will the preferred option be implemented?
- Hydro does not give any warning when levels are quickly dropped.
- Don't forget about the Lake Nipigon speckled trout.
- Any new arrangement should be implemented as an amendment to the existing Water Power Lease.
- A flow of 170 m^3/s on the river is not tolerable.
- What about walleye and pickerel?
- For a year after 1990 landslide, Ontario Hydro stabilized flows. Why can they not do it now?
- Which does MNR consider to be more important - the fish on the lake or on the river?
- Let's do it right. We are not out to "get" Hydro - but everyone must be considered.
- Everybody has to compromise! The environment has to compromise too!

Comment sheets were available at the meetings for the people to record their views and concerns. The five preliminary options were outlined on the back of the comment sheet. The sheets also asked the people to rank the importance of various criteria that could be used to assess the options. So far, 9 comment sheets, plus 2 additional written submissions, have been returned to the Study Team. Each of the Preliminary Options was identified at least once as being unacceptable. Option C was identified several times as being unacceptable because the average daily flow rates permitted too much fluctuation. The views expressed in the comment sheets were similar to those raised at the public meetings. A sampling of the comments is as follows:

- The lake should be considered as more important because it is more pristine than the river.
- Fish and wildlife habitat should always be ranked more important than anything else. The lake and river levels should be considered together.
- If you protect the fish and shoreline, traditional lifestyles will be preserved.
- Use the Ogoki to better control the level of Lake Nipigon.
- All stakeholders must realize that others must have at least an equal say.
- I would like to keep a good traditional lifestyle for our future generations.
- Maintain a constant level in both the river and lake.
- Level of Polly Lake and Lake Helen should be one-half to one foot higher than on June 1, 1993 and stable.
- Hope it is not a waste of time and money only for Hydro to do what they want anyway.

On the comment sheets, the people were asked to rank the various criteria from 1 (most important) to 8 (least important). The results of the ranking are provided in the table below.

Number of times a Criterion was given a certain rank is indicated by "*"

Criteria\ Rank	1 (most)	2	3	4	5	6	7	8 (least)
fish & spawning habitat	***** **							
loss of traditional lifestyles		*	*	*		***	*	*
boating problems		**	**		**	**		
cost of electricity	*			*			*****	*
shoreline erosion	**	***	*		**			
property damage	*		***	*	*	*		
loss of recreational use		*	*	***	*	*		
Additional criteria suggested by respondents								
deterioration of water quality		*						
bird, duck, loon nesting habitat	*							
introduction of other species (salmon)								*

CONCLUSIONS

Following the public meetings, the Study Team concluded that we had successfully identified all the users, their various interests and the conflicts between the interests. People did express opinions that the report placed too much emphasis on certain users or issues and not enough emphasis on some of the other issues. This divergence was often based on some differences in the users' interests on Lake Nipigon and the lower Nipigon River. Nevertheless, there appears to be a strong consensus that fish habitat and spawning and the overall environment are the most important considerations. Also, remarks were consistently made that the preferred solution would be a compromise. Generally people expressed an appreciation of other people's interests. They were hopeful that finally, all the interests were going to be considered fairly.

Appendix B

Terms of Reference
Nipigon River Water Quantity Management
Working Group

July 20, 1993

TERMS OF REFERENCE
NIPIGON RIVER
WATER QUANTITY MANAGEMENT WORKING GROUP

Background

Atria Engineering has been contracted by the Nipigon River Management Committee (which includes representatives from the Ontario Ministries of Natural Resources and Environment and Energy, Ontario Hydro, the Nipigon Remedial Action Plan - RAP - Team and Public Advisory Committee) to establish - with as high a degree of community consensus as possible - a preferred option for managing water quantities in the Nipigon River.

In the first year, stakeholders in the Nipigon River, Lake Nipigon and Lake Helen region were interviewed. Some stakeholders living outside the region, but who use the river, were also interviewed. As well, all available data was collected.

A report which outlines the uses and conflicts, stakeholder concerns and a preliminary set of management options was released in May, 1993. All those interviewed, as well as other interested parties received a copy of the report.

The report is to be the subject of three public meetings to be held on June 8, 9 and 10, 1993.

In this, the second year of the project, a preferred water quantity management option for the Nipigon River will be determined.

The Nipigon River Water Quantity Management Working Group

Atria Engineering is establishing the Nipigon River Water Fluctuations Working Group - a community-based working group - to assist in the selection of the preferred option.

The preferred option will be determined in consultation with the working group. A draft final report detailing the preferred option will be released for community review before it is finalized and submitted to the Nipigon River Management Committee by the end of March, 1994.

Objectives of the Water Quantity Management Working Group

The objectives of the Working Group are to:

1. review with Atria the comments received during the public meetings in June as well as any written comments that are submitted;

2. represent the range of community interests and concerns and assist in the work leading to the selection of a preferred option;

3. provide a forum for other community members to present their views and options; and

4. assist Atria in developing a consultation program for the review of the preferred option by the wider community.

Steps in the Planning Process

The preferred option will be selected through:

1. narrowing the list of potential options to a list of the most feasible options;

2. determining the relative weights of selection criteria to be used to review the options;

3. identifying in-depth research needs concerning the environment and/or costs/benefits of the feasible options;

4. applying the weights of the selection criteria (benefits and costs) by using the Multi-objective Optimization Model; and

5. considering comments made during the consultation program on the preferred option.

Membership

Atria Engineering
Anglers & Hunters
Charter Boat Operators
Commercial Fishing Operators
Cottagers
Environmental Groups
Fish and Game Clubs
General Public
Gull Bay First Nation
Lake Nipigon Ojibway First Nation Band
MNR's Lake Nipigon Advisory Committee
Municipal Governments
Nipigon RAP Public Advisory Committee
Red Rock (Lake Helen) First Nation
Rocky Bay First Nation
Sandpoint First Nation
Tourist Operators
Whitesand First Nation
1850 Treaty Council

Note: The Working Group may decide to assign additional members to represent the categories identified above at its first meeting.

The Nipigon River Water Quantity Management Committee will have observer status.

Members will be asked to:

- review the comments made during the consultation on the first report;
- make recommendations on a "most feasible options" list;
- review and comment on all research done on the feasible options list;
- determine the weights for the criteria;
- help plan any public information or consultation activity;
- review and comment on the preferred option report;
- review the comments made during the preferred option consultation; and
- work to develop a consensus on a preferred option.

Members do not have to represent any position other than their own. However, they must be prepared to consider differing positions of others.

Members may send an alternate to any meeting if they are unable to attend a meeting. The alternate can vote as a regular member. The alternate will be responsible for briefing the regular member on what happened at the meeting.

Operating Rules:

Atria Engineering will chair the Nipigon River Water Quantity Management Working Group.

The Working Group will meet seven times.

The first meeting of the Working Group will be on Thursday, June 24, 1993 in Nipigon from 7:00 p.m. - 9:30 p.m. The location and time for all other meetings (which will begin in September and run through March 1994) will be determined by the members of the working group.

Minutes of all meetings will be taken and distributed to working group members at least two weeks prior to the next meeting.

Information required by the group will be provided in a timely manner.

Previous decisions made by the Working Group can be raised for reconsideration. Any member requesting that a decision be reconsidered will be asked to provide a written rationale to the chair for distribution to all other members.

All Working Group meetings will be open to the public. Each agenda will allow for non-members to express their opinions. Those wishing to make a formal presentation to the working group will be required to notify the chair that they wish to make a presentation to the group.

It will be chair's responsibility to ensure the smooth running of Working Group meetings and that all members have an opportunity to contribute to the discussion. The chair also will be responsible for working with the group in trying to reach a consensus on a preferred option. A consensus means full agreement; where consensus is not reached, more than one preferred option will be recommended in the final report.

Appendix C

- *UPDATE* newsletter, January 27, 1994
- Notice of Working Group Meetings Sent to Local Media
- News Release (October 13, 1993)
- Lake Nipigon Watch Dog Society Newsletter Article (Summer 1993)

UPDATE

January 27, 1994

NIPIGON RIVER
DEVELOPMENT OF A WATER MANAGEMENT PLAN

This update is to keep you informed on the progress of the development of a water management plan for the Nipigon River watershed.

In the November UPDATE issue, we had told you that the second report, entitled the ***Options Report***, would be released in December, 1993. We were not able to meet that target. However, we did present the December 1993 report to the community-based Working Group and to other stakeholders on January 12 and 13, 1994. Based on comments received from these groups and on a further evaluation of the computer modelling it was apparent that we, the Study Team, needed to do a better job.

We have now refined the computerized options model to make it work better. We are also reviewing the comments we received as a result of the January, 1994 meetings and are in the process of making the appropriate revisions to the report. The results in the revised report will be an improvement over the results in the December 1993 report because of the better model and the comments.

The Study Team will brief the Working Group about the progress of the revised results at the February 2 meeting in Nipigon. At that time we will also discuss a new schedule for the release of the ***Options Report***. We will keep you advised of the next steps.

If you have any questions or require more information, please contact Mark Kolberg, Project Manager, at Atria Engineering Hydraulics Inc. (telephone (905) 891-0020).

Atria Engineering Hydraulics Inc.

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From: MARK KOLBERG

Date: August 31, 1993

Original to follow: By Mail___ By Courier___ No_x_

RE: DEVELOPMENT OF A WATER MANAGEMENT PLAN FOR THE NIPIGON RIVER

- Announcing second meeting of community-based Working Group:

  Date: Wednesday, September 8, 1993
  Place: Legion Hall, Nipigon, Ontario
  Time: 7:00 - 9:30 p.m.

- Please note that the **meeting is open to the public**.

- If you have any questions please call MARK KOLBERG, phone No. (416) 891-0020 at Atria Engineering Hydraulics Inc.

- Attached are the following:
  - Meetings Schedule
  - Agenda for Meeting #2, September 8, 1993
  - Terms of Reference for Working Group

Sent: ALS ✓

SELECTION OF A PREFERRED MANAGEMENT OPTION FOR THE NIPIGON RIVER - ONE STEP CLOSER -

For Immediate Release - October 13, 1993

The Nipigon River Water Quantity Management Working Group has established important social and value considerations for use in a computer modelling exercise that will help determine a preferred management option for Ontario Hydro's Nipigon River hydroelectric dams.

At their October 1993 meeting, the community-based Working Group, chaired by Atria Engineering, reviewed the computer program which will assist in developing an optimum operating strategy for all the stakeholders on the Nipigon system before setting community-defined "penalty functions" and "weights" to be used in the modelling. All this information will help to determine a preferred option for operating Hydro's dams on the Nipigon river in order to reduce the impacts of fluctuating water, primarily on the fishery.

The multi-agency Nipigon River Management Committee, which was formed in response to water use goals set through the Nipigon Remedial Action Plan process, contracted Atria Engineering of Mississauga, Ontario, to work with the affected community to establish - with as high a degree of consensus as possible - a preferred option for managing water quantities in the Nipigon River.

The results of the modelling will be reviewed at the Working Group's November 3, 1993 meeting. The preferred option will undergo wider community consultation.

All Working Group meetings are open to the public to attend. The meetings are held in the Legion Hall in Nipigon and start at 7:00 p.m.

For further information contact:
Mark Kolberg, Atria Engineering
(905) 891-0020

The Watch Dog Barks

Printed on Recycled Paper

Published by
Lake Nipigon Watch Dog Society
Box 133, Beardmore, ON, POT IGO

As Free As the Wind Blows

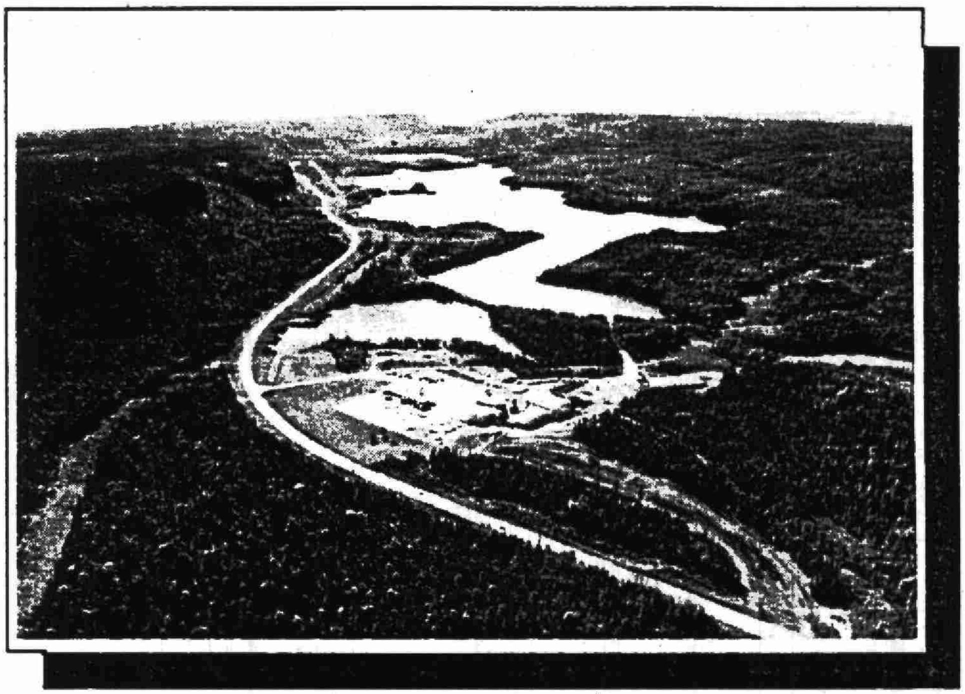
Summer 1993 Volume 2, Number 2

TCPL produces power profitably and cleanly

The buildings at Station 75 of TransCanada PipeLines (TCPL) gleamed ghostily in the intermittent rain on Monday, July 19, 1993. Streams of mist feathered the space between the damp earth and the dark overcast in one of the prettiest valleys in the North. This is the site of one of the most successful recent experiments in electrical generation.

The TCPL compressor station began operation in 1962 beside Keemle Lake, a few kilometres south of Orient Bay on Lake Nipigon, and 36 kilometres north of Nipigon. Two industrial natural gas-fired turbines with a total capacity of 13,000 horsepower (HP) assisted 57 other compressor stations to propel natural gas from British Columbia, Alberta, and Saskatchewan, across Northern Ontario, to Eastern markets.

The turbines burnt the planet's most environmentally friendly fossil fuel - natural gas. The process produced one major waste product - water, in the form of vapour or steam, which was discharged into the atmosphere. In March 1990, TCPL replaced the two turbines with a Rolls-Royce RB211 jet plane engine/turbine of 40,000 HP. Someone along the way asked, How can all that exhaust heat be utilized?



Keemle Lake stretches away south. Nipigon Power Plant is the complex at the extreme right with three structures at different levels. The TCPL right-of-way parallels the highway on the west side. TCPL photo

TCPL's Power Generation Group figured that the waste energy could drive a steam turbine to generate enough electricity to supply every home, camp, and business between Keemle Lake and Longlac - but the operation would not generate a profit. If, on the other hand, the waste energy were to supplement a

Continued page 4

Managing the water levels of river and lake

I am pleased with the way the study team for Nipigon River Management Committee have come into this area with an open mind, listening to all who speak up, and not showing any preconceived notions. I would like to offer some suggestions.

I have heard a rumour that Ontario Hydro is in favour of the construction of a fish hatchery on Lake Nipigon. I have also heard objections to such a proposal. I suggest that the proposal may divert attention from the problems caused by fluctuating water levels in Lake Nipigon.

A fish hatchery is only a small part of the solution. There is the possibility that diseased fish may be released directly into the lake, for you have heard of past problems with diseased fish in the Dorion hatchery. But more importantly, I believe the release of fingerlings would be absolutely useless

Continued page 2

From page 1

Water levels

in the river and next to useless in the lake if the water level is low.

I believe the food chain upon which the fingerlings would depend, is in jeopardy. I estimate that the released fish would have to be at least six inches long in order to survive. My brother will explain about the food chain in another article in this issue.

For the past twelve years, my brother has surveyed over 500 lakes in Northwestern Ontario for the crustaceans that are the beginning of the food chain. He does this as a hobby, but his work is recognized a national museum in Ottawa, which accepts and keeps his records.

I presented to the study team the idea of using the Ogoki Reservoir to minimize the fluctuations of levels in Lake Nipigon. The Reservoir would be managed in concert with all tributaries of Lake Nipigon to maintain a near steady level in the lake and Nipigon River. In this plan, flows in all tributaries would have to be electronically and remotely monitored.

I recognize that Hydro allows a large spread between high and low water levels. Even if it takes an Order-in-Council, I think an optimum lake level and downstream flow should be set, and very little variation from those levels should be allowed.

How could peak power demands be met? The Mission Island plant could supply extra power on demand. Better yet, TransCanada PipeLines could be encouraged to build a second plant locally (like the Nipigon Power Plant near Orient Bay) which could generate a steady output.

Working together, it is possible to make Lake Nipigon and the Nipigon River vastly improved fish habitats.

J.R. "Bud" Lindeman

Memberships Available
Be guaranteed a copy of ***TWDB***
Send $10 along with address and phone number

Study team visits Beardmore

In the photo above, fisheries biologist Christopher Wren displays a section of the Nipigon River below Alexander Generating Station. He points to the scar marking the area that slid into the river on April 23, 1990. A contributing cause was rapid fluctuations of water levels by the GS. An interim agreement between Hydro and MNR currently specifies minimum river flow.

Wren was a member of the study team for Nipigon River Management Committee when the team presented its Draft Options Report at the Evergreens Building in Beardmore on June 10, 1993. Mark Kolberg of Atria Engineering Hydraulics Inc. stated that the goal is to stabilize the flow in the Nipigon River so that fluctuations occur between acceptable limits. A secondary consideration is to minimize fluctuations in Lake Nipigon.

David Evans of Atria Engineering, third member of the team, said that the first year of study has been completed. In the second year, a Working Group of interested groups and citizens will study the options and make suggestions. The Group will meet six times between September 1993 and January 1994. The ***Lake Nipigon Watch Dog Society (LNWDS)*** is a member.

At the end of the Group meetings, the study team will present the results to the wider community for comment.

The Lake Nipigon District Booster

Appendix D

- Executive Summary of Laboratory Study on the Effects from Redd Dewatering Under Winter Conditions on Brook Trout and Round Whitefish Egg and Larval Survival, Ontario Hydro Report 93-173-K, by J.S. Griffiths, M.L. MacIntyre and E.A. McLeod, September 30, 1993.

- Correspondence to G. Pope, Ontario Hydro, from E. Snucins and J. Gunn, Ministry of Natural Resources, dated August 27, 1993.

- Correspondence to E. Snucins and J. Gunn, Ministry of Natural Resources, from G. Pope, Ontario Hydro, dated October 15, 1993.

- Correspondence to G. Pope, Ontario Hydro, from M. Ridgeway, Ministry of Natural Resources, dated November 30, 1993.

new 82-10

ontario hydro
research division

EXECUTIVE SUMMARY

LABORATORY STUDY OF EFFECTS FROM REDD DEWATERING UNDER WINTER CONDITIONS ON BROOK TROUT AND ROUND WHITEFISH EGG AND LARVAL SURVIVAL

J.S. Griffiths, M.L. MacIntyre and E.A. McLeod

The Ontario Ministry of Natural Resources has observed the exposure of brook trout redds in the lower Nipigon River. This exposure was due to river flow regulation by Ontario Hydro. Redd dewatering occurs during low flows in the late winter and early spring, and the problem can be exacerbated by irregular flows associated with peaking operations of hydraulic plants on the river. The MNR has requested that Hydro maintain a minimum flow level in the river which would effectively eliminate peaking throughout most of the winter and spring in dry years. Hydro wishes to continue peaking during the late winter and early spring if developing eggs will not be adversely affected. The objective of this study is to assist Hydraulic Operations to determine whether flow regulation of the Nipigon River associated with peaking operations has deleterious effects on incubating brook trout eggs and larvae.

A computer simulation study was conducted to determine the time period when hatched larvae would be expected in the gravel of the Nipigon River, as previous studies on the Columbia River (Becker et al, 1982) suggested that newly hatched larvae were extremely intolerant of dewatering. The computer model utilized brook trout egg development rate data from Garside (1966) to calculate hatch dates and a splake (brook x lake trout) model to calculate times from hatch to emergence. The model operated on a daily step function, using observed Nipigon River temperatures (October 1992 to June 1993) as input.

The simulation study has indicated that the timing of egg hatch and larval emergence in the Nipigon River is strongly affected by the date of spawning, due to warm temperatures prevailing in late October and early November. Spawning dates of October 8, October 22 and November 5 yielded predicted median hatch dates of January 16, March 8 and April 13. Predicted larval emergence dates were February 11, April 1 and May 2, respectively. The first, median and last hatch models also indicate that a considerable further spread in hatch and emergence times can occur, but most eggs will hatch near the time predicted by the median hatch model. The simulations indicate that even moderate warming from groundwater flows could have very large effects on dates of egg hatch and larval emergence. Field assessment of within-redd temperatures and groundwater flows is suggested.

Laboratory studies were conducted using an artificial redd apparatus to determine effects from dewatering under freezing conditions on brook trout larvae. As the brook trout eggs being held in the laboratory had hatched by the time the apparatus was completed and tested, bioassay experiments were conducted using brook trout larvae and near-term round whitefish eggs to determine if there was any gross difference in the resistance of eggs and larvae.

job	file	date	report no.
91-186-592	837.321	September 30, 1993	93-173-K

Physical tests were conducted to establish operating characteristics and cooling curves for the artificial redd apparatus. When dewatered and drained (starting at 3°C) in air temperatures near -25°C, the apparatus cooled slowly from the top downwards, suggesting that it was sufficiently insulated on the sides and bottom to mimic the thermal mass of a natural redd. The gravel in the redd froze to a depth of 10 cm within 6 to 8 hours, to a depth of 20 cm within 14 to 16 hours and to depth of 30 cm within 16 to 20 hours. In milder temperatures (-7.8°C), freezing times were extended, as the 10 cm temperature probe froze after 16.7 hours and the 20 cm and 30 cm depths froze after 36 to 37 hours. The addition of a 30 cm layer of snow and ice also slowed cooling rates. At -25°C, the 10 cm probe required 25 hours to freeze, while the 20 cm probe required 36 hours when the surface was snow covered. Tests conducted using a subsurface seepage flow at 3°C (to simulate springs in the riverbed) indicated that eggs or larvae within this flow would be protected from freezing, and would not suffer any mortality, while those above the flow might also survive.

Bioassay tests were conducted using brook trout larvae and round whitefish eggs (most hatched during tests) under the most extreme single event dewatering scenario (20 hour dewatering at -25°C). Subsurface flows of 10, 20, and 30 cm/hr (3°C water) were used, at a depth of 33.5 cm below the gravel surface. There was complete mortality of brook trout and round whitefish at 10 cm depth, but no significant brook trout mortality at greater depths. Survival of completely dewatered brook trout larvae (at 20 cm depth) for 20 hour periods was unexpected, and appears due to the high humidity and near freezing temperatures under the frozen gravel. Mortality of dewatered round whitefish (mostly hatched larvae) was higher, averaging 22.8% at the 20 cm depth. In those cases where round whitefish eggs and larvae could be compared, there was no apparent difference in freezing resistance.

Subsurface flow rates did not substantially alter cooling curves or bioassay results in tests at 20 and 30 cm/hr. Tests at 10 cm/hr resulted in freezing of outflow lines and inadvertent rewatering of the apparatus. However, these tests clearly showed that an upwelling flow of even 10 cm/hr was sufficient to thaw the frozen gravel surface and prevent it from further freezing, thus protecting eggs and larvae.

Two multiple dewatering tests were run using 20 hour dewatering periods (4 hours rewatering) over 3 day durations. Temperature decay profiles each day were very similar to those in the single 20 hour tests. Results indicated somewhat higher mortalities for both species than was observed in the single 20 hour dewatering tests. In both single and multiple tests, there was total mortality of brook trout and whitefish at 10 cm depth. In the multiple tests, both species also experienced total mortality at 15 cm (depth not tested in single tests). In the single tests, no brook trout died at 20 cm depth, while the average mortality (20 and 25 cm depths) was 17% in the 20 hour multiple dewatering tests. Round whitefish were substantially more susceptible than brook trout, with 55.8% mortality at these depths, compared to 22.8% in the single tests.

Two final multiple dewatering tests were conducted using a cycle of 8 hour dewatering and 16 hour rewatering over a 3 day period. Temperature curves at the 10 cm depth in these tests were generally similar to those at the 20 cm depth in the single 20 hour tests. Minimum temperatures at 10 cm ranged from about -1°C to -2.5°C during each dewatering, while the gravel did not freeze at the 20 cm and 30 cm depths. Mortalities in the 8 hour multiple dewatering tests were low for brook trout, averaging 8% over the 10 to 20 cm depths. Round whitefish mortalities over the 10 to 25 cm depth were higher, averaging 33%. Both species showed somewhat higher mortalities than observed under generally similar temperatures in the single event dewatering test. This may in part be due to slightly colder minimum temperatures during the first cycle of the multiple tests. However, some mortality in 20 to 25 cm deep chambers (which did not freeze) suggests that repeated dewatering may itself cause some mortality, especially in round whitefish.

When this study was begun, it was assumed that dewatering of hatched larvae should be avoided at all costs, as literature data (Becker et al, 1982) indicated that larvae were extremely intolerant of dewatering. However, our laboratory results suggest that dewatering of brook trout larvae in near freezing conditions is less harmful than previously believed. Field verification of these results is suggested.

MKL	AEN	JEP

Ministry of Natural Resources — Ministère des Richesses naturelles

Ontario

FEED FAX THIS END

FAX

To: MARK KOLBERG
Dept.:
Fax No.: 416-891-0071
No. of Pages: 2
From: KEN CULLIS
Date: SEPT 13/93
Company: RAP
Fax No.:
Comments:

fax pad 7903E

Post-it

R. Swainson

August 27, 1993

Gregory F. Pope
Senior Design Specialist
Ontario Hydro
700 University Ave.
Toronto, Ontario M5G 1X6

SUBJECT: Study of the effects of redd dewatering on brook trout egg and alevin survival in the Nipigon River.

Dear Mr. Pope,

In your letter dated August 6, 1993 regarding the results of the laboratory study by Griffiths et al. (1993) and proposal for future field work you suggest that "if the eggs and larvae are protected by a groundwater flow during a dewatering event, there will be no mortality". That statement, however, is not supported by the data from the laboratory study. On the contrary, the results indicate that there will indeed be mortality associated with dewatering. In the laboratory experiments, multiple dewaterings of 20 hours/day duration resulted in 100% mortality at 10 and 15 cm depths and 17% mortality at 20 and 25 cm depths. Multiple dewaterings of 8 hours/day duration resulted in 8% mortality at 10-20 cm depths. The mortalities occurred at depths that correspond with the depth of egg pockets in natural brook trout redds.

In addition, the multiple dewatering treatments were of short (3-day) duration and undoubtedly underestimated the mortality experienced in the field during repeated dewaterings over an entire fall and winter incubation period. Becker et al. (1982) subjected chinook salmon alevins to 20 consecutive dewaterings and they reported a greater sensitivity by embryos than was observed in the Griffiths et al. (1993) study.

Sublethal effects of dewatering on growth and rate of development were not measured in the laboratory study, but these could have significant effects on brook trout survival. Dewatering alters the thermal experience of incubating eggs and alevins, affecting development rates and size at emergence, both of which have ecologically significant consequences. Becker et al. (1982) found that the growth of chinook salmon embryos was reduced by dewatering. Many researchers have found that embryo growth has considerable effects on long term survival.

The proposed 1993-1994 field study of brook trout redds in the Nipigon River makes no mention of monitoring groundwater flow dynamics, a very critical variable in this investigation. In addition, although the data gathered by the proposed field work would be of scientific interest, we are concerned that some of the activities will kill large numbers of brook trout embryos. Freeze-coring of natural redds, installation of egg baskets in redds for in-situ egg incubation, and deliberate dewatering of redds will destroy wild embryos. The proposed in-situ monitoring during the deliberate dewatering of natural redds may not be sufficient to avoid embryo deaths because of the lag in reestablishing water flow over the redds once freezing of the substrate is detected.

It is clear from the results of the laboratory study that dewatering will be lethal to brook trout early life history stages. Therefore, we recommend that the proposed field study not be conducted and that the spawning sites of the provincially important brook trout stock in the Nipigon River be protected from dewatering.

Ed Snucins

John Gunn

Cooperative Freshwater Ecology Unit
Ontario Ministry of Natural Resources
Dept. of Biology, Laurentian University
Sudbury, Ontario P3E 2C6

cc. D. Evans, M. Ridgway, R. Swainson

ontario hydro

700 University Avenue, Toronto, Ontario M5G 1X6

Cooperative Freshwater Ecology Unit
Ontario Ministry of Natural Resources
Dept. of Biology
Laurentian University
Sudbury, Ontario
P3E 2C6

Att: Ed Snucins
John Gunn

October 15, 1993

RE: Nipigon River Flow Regulation
Effects of Redd Dewatering on Brook Trout Egg and Alevin Survival in the Nipigon River

Dear Ed

This letter is in response to your letter of August 23, 1993 commenting on our laboratory experiments and recommending that field studies not be undertaken.

As I explained earlier by telephone, our interpretation of the results of the laboratory experiments is that if the eggs and larvae remain immersed in a groundwater flow during the peaking decay cycle, mortality will not occur even if the exposure lasts as long as 20 h. This was our original hypothesis and the basis for study design proposed in the fall of 1992 (letter of October 6, 1992). However, in response to Curry et al's (1992) results, we also simulated the effects of a change in groundwater flow path as a result of peaking decay. At cold temperatures (e.g. -25 °C), rapid freezing of the shallower dewatered substrate did occur and there was mortality of eggs and larvae as you point out in your

letter. At more moderate temperatures (> -8 °C), freezing and mortality could still occur, but possibly not within a short peaking cycle.

The critical question that arises from the laboratory experiments appears to be the effect of peaking decay on groundwater flow. If groundwater flow paths are not unduly disrupted over a brief dewatering cycle of 6 to 20 h, there may be no mortality of eggs and larvae during dewatering. If there are rapid changes in groundwater flow paths during peaking as suggested by Curry et al (1992), then freezing may occur in shallow redds in as little as 6 h. We believe that the field survey proposed for 1993/4, using the methodology developed for the laboratory experiments, could have resolved this issue.

In your letter of August 27, 1993, you expressed concerns about the brief duration of the 3 d multiple dewatering treatments and potential sublethal effects of dewatering on growth and rate of development. Originally, Hydro had proposed two years of laboratory studies and we had intended to address your first concern during the second year. However, we see little advantage to continuing the laboratory studies for a second year until we resolve the question of the effect of peaking on groundwater flow paths. If a field experiment confirmed that peaking had no effect on the groundwater flow paths over brief peaking cycles and that freezing of the redds did not occur, we would be prepared to undertake laboratory experiments of longer duration and to investigate sublethal effects.

With regard to your comments on the monitoring of groundwater dynamics, monitoring of groundwater temperature with the thermistors provides a good indirect measurement of groundwater flow dynamics as illustrated by the laboratory experiments.

You also expressed concern about potential impacts of the experiment on the 1994 year class of brook trout in the Nipigon. We wish to note that it was the MNR scientific advisory group and not Ontario Hydro that requested a field confirmation of the laboratory results (meeting of September 22, 1992, letter of October 6, 1992). The freeze-coring and installation of egg baskets would provide interesting information, especially on the depths of redds, but are perhaps not essential to the issue. Nevertheless, the resulting mortality to eggs from such activities must be insignificant compared to the effects of the sport fisheries on spawning adults.

We believe that a peaking experiment of one or two weeks duration can be conducted with limited risk to the redds if there is real-time monitoring of results. Moreover, we wish to emphasize that Ontario Hydro has been peaking the Nipigon River for almost 50 years so we don't believe that the experiment poses an imminent risk to the trout resource. However, based on your recommendation not to proceed with the field experiments, we have cancelled the

proposed study for this year.

We certainly wish to thank you for your participation in the scientific advisory group and appreciate your comments on our work and your prompt response to our letter.

Yours very truly

Gregory F Pope
Senior Environmental Specialist

cc: M Ridgway, R Swainson, K Cullis

Ontario
Ministry of Natural Resources
Ministère des Richesses naturelles

November 30, 1993

Mr. Gregory F. Pope
Senior Environmental Specialist
Hydroelectric Business Unit
700 University Ave.
Toronto, Ontario M5G 1X6

Subject: **Laboratory study of effects from redd dewatering under winter conditions on brook trout and round whitefish egg and larval survival**

I have a number of comments on the laboratory report investigating the dewatering of artificial redds. My comments fall into four areas.

First, the duration of the experiments was very short relative to the proposed time period that river levels would be manipulated during peaking. The time period for proposed peaking is late winter and early spring which is much longer than a three day experiment. The study by Becker et al (1982), which you criticize, lasted twenty-two days with multiple dewaterings and indicated that the late phases of development (alevins) were particularly susceptible to dewaterings. In addition, Becker et al found that the size of fish decreased as the length of daily dewaterings increased. This is not a trivial point. Smaller fish at emergence are generally more susceptible to predation and starvation than larger fish. In the case of young-of-year salmonines, decreased size also results in the inability of fish to hold feeding stations/territories which can lead to emigration from the local habitat.

Second, the proposed peaking period corresponds to the late egg and early embryo period of development in brook trout (late February to April). Your model of developmental timing confirms this observation. It is therefore unfortunate that you were unable to use brook trout eggs as part of this investigation. If you had you may have found that the effect of dewaterings would approach the observations you made on round whitefish eggs in your apparatus. Clearly these eggs had a high mortality resulting from dewatering. Would a similar effect have been observed with brook trout eggs? Round whitefish eggs are certainly smaller and perhaps more susceptible to mortality from dewatering than brook trout eggs. However, Becker et al (1982) found that frequent dewaterings lowered the survival of the most resilient stage, late egg (they refer to this period as the 'embryo' but it is really the late egg stage). These effects, as well as any effects on the early embryo stage (hatched), would be observed during the peaking period.

Third, the results from your apparatus are quite variable which is consistent with the results from Becker et al (1982). This points to the necessity of more experimental runs to counter the effects of low sample size. Part of this problem may stem from the lack of consideration of statistical power which in turn is a consequence of no clear hypothesis or effect size. Considering the consequences of accepting the null hypothesis ("no effect of dewatering on brook trout survival") it would seem apparent that this factor is a desparately important consideration.

Fourth, your data do demonstrate an increase in mortality of embryonic brook trout subject to dewaterings in short-term experiments. Immersing the embryos in 'groundwater flow' did not result in "no mortality". I had a sense that part of the variability in the experiments resulted from some uncertainty on your part concerning subsurface flow. The sequence of experimental runs at times appears to reflect this possibility. One way out of this dilemma is to consult a wider literature. Surely the hydrology and water resource literature contains the results of studies investigating the consequences of fluctuating water levels on groundwater flow and water retention in various substrates.

The unrealistically short duration of the experiments, lack of consideration of any long-term chronic effects of dewatering on trout survival, lack of data on all stages of developing brook trout, high variation in the data and the corresponding inability to draw strong conclusions, and the observation that mortality did take place in the experiment all point to problems in the recommendations stemming from this work. In my opinion, the results of this work are insufficient to justify proceeding with Hydro's proposed river fluctuations and redd dewaterings during late winter and early spring.

Sincerely,

Mark Ridgway
Harkness Laboratory
of Fisheries Research
Aquatic Ecosystems Research Section
Box 5000
Maple, Ontario L6A 1S9

cc. David Evans, Rob Swainson, Ken Cullis, Ed Snucins, John Gunn

Appendix E

Stochastic Dynamic Programming

STOCHASTIC DYNAMIC PROGRAMMING

General

Dynamic programming is a mathematical technique often useful for making a sequence of interrelated decisions. It provides a systematic procedure for determining the combination of decisions that maximizes overall effectiveness. The release of water from Pine Portage Generating Station could be considered as a sequence of decisions which can be optimized for power generation.

Unlike linear programming, there is no standard mathematical formulation of the dynamic programming problem. Rather, dynamic programming is a general type of approach to problem solving, and the particular equations used must be developed to fit each individual situation, hence a certain degree of insight on how the problem can be solved by dynamic programming procedures is required. To illustrate how dynamic programming procedure is used to solve a problem, let us look at a simple *stagecoach* problem.

Stagecoach Problem

Consider a salesman who has to travel from City 1 to City 10 by stagecoach as illustrated in Figure 1. Although his starting point and destination are fixed, he has considerable choices as to which city to travel through en route. The possible routes are also shown in Figure 1. There are four stages required to travel from City 1 to City 10. However, the salesman's company has a policy that he must travel on the route with the lowest cost. The cost from City i to City j will be denoted as c_{ij} and is shown in Table 1. One strategy to determine the route of lowest cost is to find out all the possible routes, such as 1~2~5~8~10, 1~2~6~8~10, etc. and compute the total cost for each route. However, the number of possible route is large(18) and this approach is not appealing. If more cities and stages are considered, the task of computing total cost of each possible route becomes an exhaustive exercise.

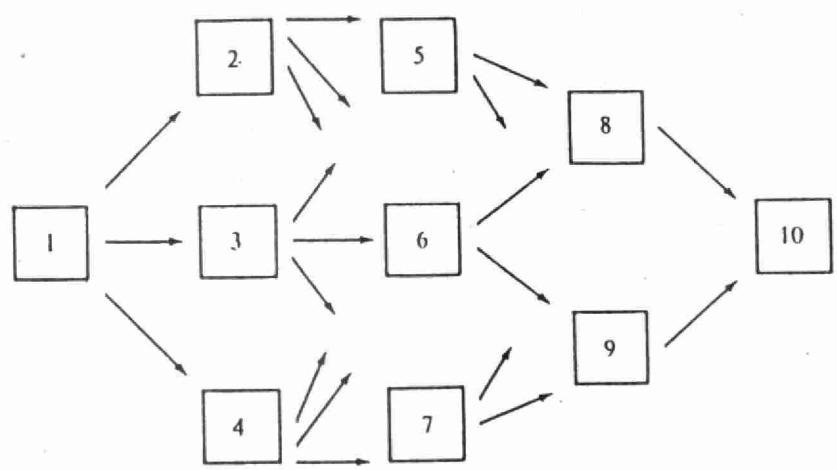


Figure 1 The road system for the stagecoach problem.

Table 1 Stagecoach costs

	COST, c_{ij}									
CITY j i	1	2	3	4	5	6	7	8	9	10
1		2	4	3						
2					7	4	6			
3					3	2	4			
4					4	1	5			
5								1	4	
6								6	3	
7								3	3	
8										3
9										4
10										

The dynamic programming approach is to start with a small portion of the problem and find the optimal solution for this smaller problem. It then gradually enlarges the problem, finding the current optimal solution from the previous one until the original problem is solved entirely. For the stagecoach problem, the dynamic programming aproach will break the problems into 4 stages and starts to solve the problem backward. First, let us define some variables for this problem. Let the decision variables x_n (n=1,2,3,4) be the immediate destination on stage n. Thus the route selected would be $1 \sim x_1 \sim x_2 \sim x_3 \sim x_4$, where $x_4 = 10$ (i.e. City 10). Let $f_n(s,x_n)$ be the total cost of the route when the salesman is in City s and selects x_n as the immediate destination. Given s and x_n, let x_n^* denote the value of x_n that minimizes $f_n(s,x_n)$ and let $f_n^*(s)$ be the corresponding minimum value of $f_n(s,x_n)$. Thus, $f_n^*(s) = f_n(s,x_n^*)$. The objective is to find $f_1^*(1)$ and the successive $f_2^*(s)$, $f_3^*(s)$ and $f_4^*(s)$.

Since dynmaic programming solves the problem backward, the immediate solution for stage 4 (the destination) can be found in the following table.

s	$f_4(s,x_4) = c_{sx4}$			$f_4^*(s)$	x_4^*
	x_4				
	10				
8	3			3	10
9	4			4	10

For stage 3, the solution requires a few calculations. Assuming that the salesman is in City 5, he must decide to go to either City 8 or 9 at the cost 1 or 4 respectively. If City 8 is chosen, the total cost to the destination for this decision would be 1+3=4. Similarly, the total cost for City 9 is 4+4=8. Therefore he would choose City 8, x_3^*=8, because it gives the minimum total cost, $f_3^*(5)$=4. Accordingly, $f_3^*(6)$ and $f_3^*(7)$ can be found for s=6 and s=7 respectively. The results are shown in the following table.

s	$f_3(s,x_3) = c_{sx3} + f_4^*(x_3)$			$f_3^*(s)$	x_3^*
	x_3				
	8	9			
5	1+3=4	4+4=8		4	8
6	6+3=9	3+4=7		7	9
7	3+3=6	3+4=7		6	8

The solution for stage 2 is obtained in a similar fashion. In this case, $f_2(s,x_2) = c_{sx2} + f_3^*(x_2)$. The results are shown as below:

s	$f_2(s,x_2) = c_{sx2} + f_3^*(x_2)$			$f_2^*(s)$	x_2^*
	x_2				
	5	6	7		
2	7+4=11	4+7=11	6+6=12	11	5 or 6
3	3+4=7	2+7=9	4+6=10	7	5
4	4+4=8	1+7=8	5+6=11	8	5 or 6

The solution for stage 1 (point of embarkment) is also obtained in a similar fashion. In this case, $f_1(s,x_1) = c_{sx1} + f_2^*(x_1)$. The results are shown as below:

s	$f_1(s,x_1) = c_{sx1} + f_2^*(x_1)$			$f_1^*(s)$	x_1^*
	x_1				
	2	3	4		
1	2+11=13	4+7=11	3+8=11	11	3 or 4

From these tables, the optimal solution can now be written. The table above shows that the salesman can choose either 3 or 4 when he starts. Suppose he chooses $x_1^*=3$, the optimal route is 1~3~5~8~10. Choosing $x_1^*=4$ will lead to two other optimal routes, 1~4~5~8~10 and 1~4~6~9~10. They all yield a total cost of $f_1^*(s)=11$.

Characteristics of Dynamic Programming Problems

The stagecoach problem is a typical example of dynamic programming problems. From this example, the basic features of dynamic programming problems can be characterized as below:

- The problem can be divided into stages, with a policy decision required at each stage.
- Each stage has a number of states associated with it.
- The effect of the policy decision at each stage is to transform the current state into a state associated with the next stage (possibly according to a probability distribution).

- Given the current state, an optimal policy for the remaining stages is independent of the policy adopted in previous stages. For dynamic programming problems in general, the current state of the system is the result of the previous states and decisions; the optimal policy from the current state onward is independent of how the current state is reached.

- The solution procedure begins by finding the optimal policy for each state of the last stage.

- A recursive relationship that identifies the optimal policy for each state at stage n, given the optimal policy for each state at stage (n+1), is available. The recursive relationship for the stagecoach problen is
$$f_n^*(s) = \text{min of } x_n \; \{ c_{sxn} + f_{n+1}^*(x_n) \}.$$
Thus finding the optimal policy when starting in state s at stage n requires finding the minimizing value of x_n which consists of the cost from s to x_n and the optimal cost when starting in state x_n at stage (n+1).

- Using the recursive relationship, the solution procedure moves backward stage by stage - each time finding the optimal policy for each state of that stage - until it finds the optimal policy when starting at the initial stage.

Reservoir Optimization Problem

For the reservoir operation problem, the reservoir storage can be considered as the stage variable. The transition between stages (or reservoir storage) may be expressed as

$$s^t = s^{t-1} + x^t - d^t$$

where s^t and s^{t-1} are the reservoir storage at time t and t-1 respectively, x^t is the inflow at time t and d^t is the reservoir discharge at time t. Given that the previous storage s^{t-1} and the current inflow x^t are known, the current reservoir storage s^t can be determined if the discharge d^t is decided. The problem here is to determine the operating policy to produce the optimal discharges.

Using the same convention in the stagecoach problem, let us define the following terms:

$f^t(s^{t-1},s^t)$	be the total cost when the storage at time t-1 is s^{t-1} and the next stage is s^t, where $s^t = s^{t-1} + x^t - d^t$;
s^{*t}	be the value of s^t that minimize $f^t(s^{t-1},s^t)$;
$f^{*t}(s^{t-1})$	be the corresponding minimum value of $f^t(s^{t-1},s^t)$; $f^{*t}(s^{t-1}) = f^t(s^{t-1},s^{*t})$ and
$c^t(s^{t-1},s^t)$	be the total cost involved in the transition from s^{t-1} to s^t.

Given s^{t-1}, s^t and x^t, the discharge at time t, d^t, is determined ny minimizing the total cost

expressed in the backward recursive equation for reservoir optimization as

$$f^{*t}(s^{t-1}) = \min \{ c^t(s^{t-1},s^t) + f^{*t+1}(s^t) \}.$$

It should be noted that the so far, the inflow to the reservoir x^t is assumed to be known at time t. However, x^t is not known but it is a stochastic variable associated with a probability function. Because of the stochastic nature of the inflow into the reservoir system, the backward recursive equation for reservoir optimization should be written as

$$f^{*t}(s^{t-1}) = \min \{ c^t(s^{t-1},s^t) + \Sigma\, p^t(s^{t-1},s^t)\, f^{*t+1}(s^t) \}$$

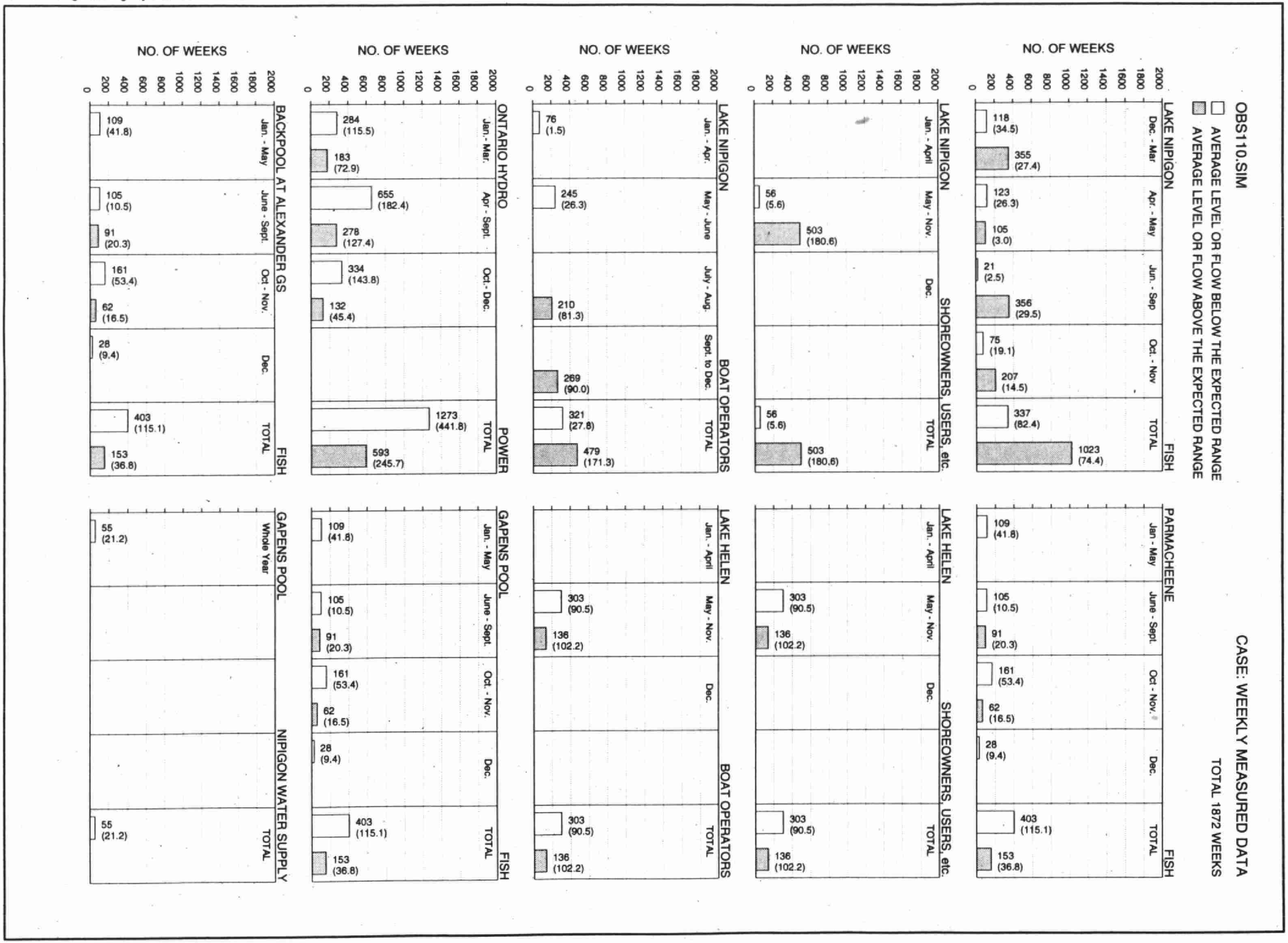
where p^t is the probability that the reservoir storage changed from s^{t-1} to s^t due to the possible inflow x^t and decided d^t. This equation is referred to as backward recursive equation for stochastic optimization. The procedure to solve this equation is the same as that for the deterministic model except that the possible values of inflow and their associated probabilities are required to be considered.

Appendix F

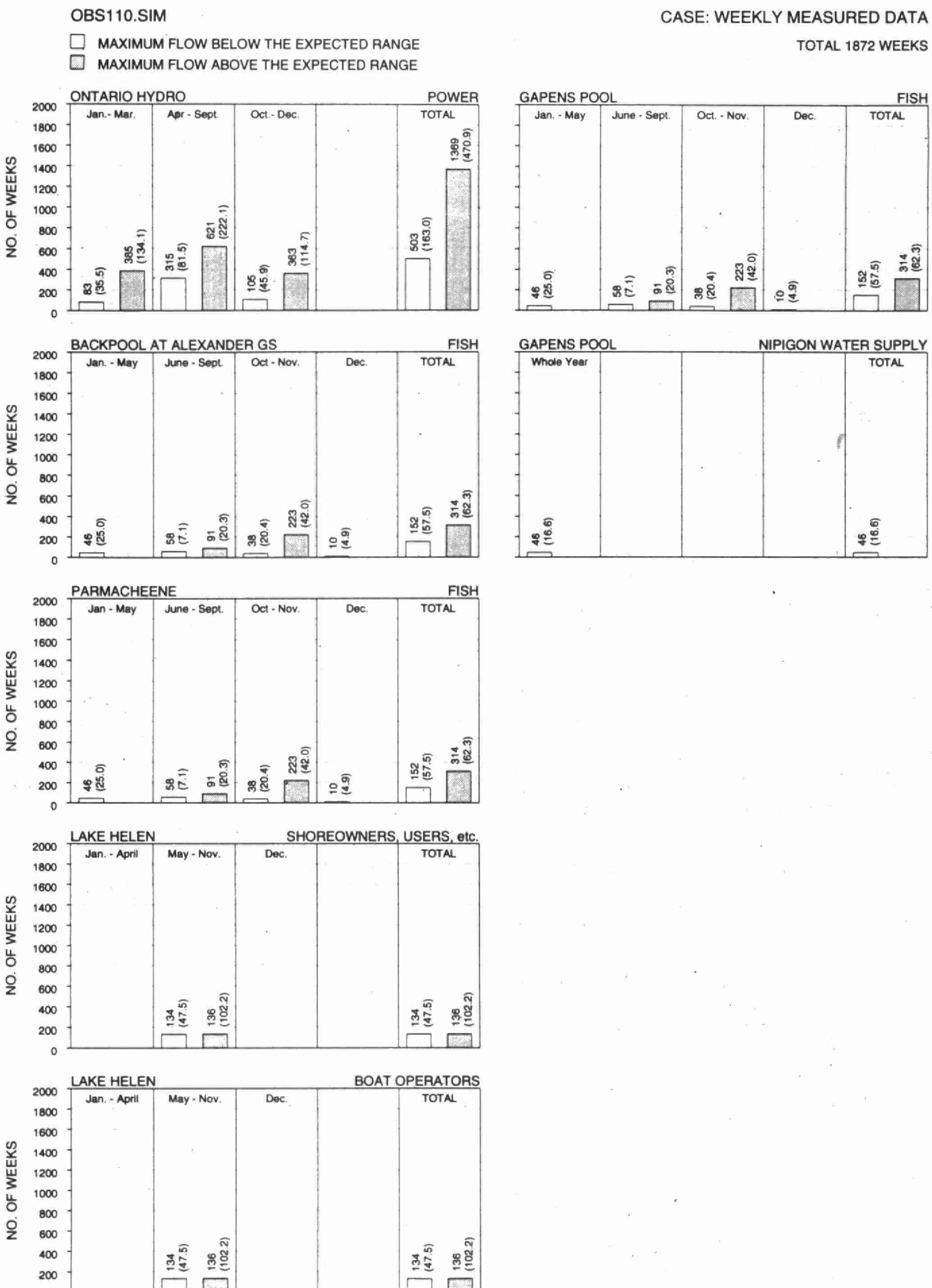
Options

Options OBS 110

- (see other options for time series)
- Performance of average Lake Nipigon level and Nipigon River flow and minimum and maximum flows relative to penalty functions
- Lake Nipigon water level data: fall to spring drawdown; maximum fall; minimum spring; peaking data
- Power produced and dollar value



OBS110.SIM
AVERAGE LEVEL OR FLOW BELOW THE EXPECTED RANGE
AVERAGE LEVEL OR FLOW ABOVE THE EXPECTED RANGE
CASE: WEEKLY MEASURED DATA
TOTAL 1872 WEEKS
NO. OF WEEKS
0 200 400 600 800 1000 1200 1400 1600 1800 2000
LAKE NIPIGON FISH
Dec. - Mar 118 (34.5) 355 (27.4)
Apr. - May 123 (26.3) 105 (3.0)
Jun. - Sep 21 (2.5) 356 (29.5)
Oct. - Nov 75 (19.1) 207 (14.5)
TOTAL 337 (82.4) 1023 (74.4)
LAKE NIPIGON SHOREOWNERS, USERS, etc.
Jan. - April
May - Nov. 56 (5.6) 503 (180.6)
Dec.
TOTAL 56 (5.6) 503 (180.6)
LAKE NIPIGON BOAT OPERATORS
Jan. - Apr. 76 (1.5)
May - June 245 (26.3)
July - Aug. 210 (81.3)
Sept. to Dec. 269 (90.0)
TOTAL 321 (27.8) 479 (171.3)
ONTARIO HYDRO POWER
Jan. - Mar. 284 (115.5) 183 (72.9)
Apr. - Sept. 655 (182.4) 278 (127.4)
Oct. - Dec. 334 (143.8) 132 (45.4)
TOTAL 1273 (441.8) 593 (245.7)
BACKPOOL AT ALEXANDER GS FISH
Jan. - May 109 (41.8)
June - Sept. 105 (10.5) 91 (20.3)
Oct. - Nov. 161 (53.4) 62 (16.5)
Dec. 28 (9.4)
TOTAL 403 (115.1) 153 (36.8)
PARMACHEENE FISH
Jan. - May 109 (41.8)
June - Sept. 105 (10.5) 91 (20.3)
Oct. - Nov. 161 (53.4) 62 (16.5)
Dec. 28 (9.4)
TOTAL 403 (115.1) 153 (36.8)
LAKE HELEN SHOREOWNERS, USERS, etc.
Jan. - April
May - Nov. 303 (90.5) 136 (102.2)
Dec.
TOTAL 303 (90.5) 136 (102.2)
LAKE HELEN BOAT OPERATORS
Jan. - April
May - Nov. 303 (90.5) 136 (102.2)
Dec.
TOTAL 303 (90.5) 136 (102.2)
GAPENS POOL FISH
Jan. - May 109 (41.8)
June - Sept. 105 (10.5) 91 (20.3)
Oct. - Nov. 161 (53.4) 62 (16.5)
Dec. 28 (9.4)
TOTAL 403 (115.1) 153 (36.8)
GAPENS POOL NIPIGON WATER SUPPLY
Whole Year 55 (21.2)
TOTAL 55 (21.2)


OBS110.SIM
CASE: WEEKLY MEASURED DATA
TOTAL 1872 WEEKS
MAXIMUM FLOW BELOW THE EXPECTED RANGE
MAXIMUM FLOW ABOVE THE EXPECTED RANGE
ONTARIO HYDRO
POWER
Jan.- Mar.
Apr - Sept.
Oct.- Dec.
TOTAL
83 (35.5)
385 (134.1)
315 (81.5)
621 (222.1)
105 (45.9)
363 (114.7)
503 (163.0)
1369 (470.9)
GAPENS POOL
FISH
Jan. - May
June - Sept.
Oct. - Nov.
Dec.
TOTAL
46 (25.0)
58 (7.1)
91 (20.3)
38 (20.4)
223 (42.0)
10 (4.9)
152 (57.5)
314 (62.3)
BACKPOOL AT ALEXANDER GS
FISH
Jan. - May
June - Sept.
Oct - Nov.
Dec.
TOTAL
46 (25.0)
58 (7.1)
91 (20.3)
38 (20.4)
223 (42.0)
10 (4.9)
152 (57.5)
314 (62.3)
GAPENS POOL
NIPIGON WATER SUPPLY
Whole Year
TOTAL
46 (16.6)
46 (16.6)
PARMACHEENE
FISH
Jan - May
June - Sept.
Oct - Nov.
Dec.
TOTAL
46 (25.0)
58 (7.1)
91 (20.3)
38 (20.4)
223 (42.0)
10 (4.9)
152 (57.5)
314 (62.3)
LAKE HELEN
SHOREOWNERS, USERS, etc.
Jan. - April
May - Nov.
Dec.
TOTAL
134 (47.5)
136 (102.2)
134 (47.5)
136 (102.2)
LAKE HELEN
BOAT OPERATORS
Jan. - April
May - Nov.
Dec.
TOTAL
134 (47.5)
136 (102.2)
134 (47.5)
136 (102.2)
NO. OF WEEKS
0
200
400
600
800
1000
1200
1400
1600
1800
2000

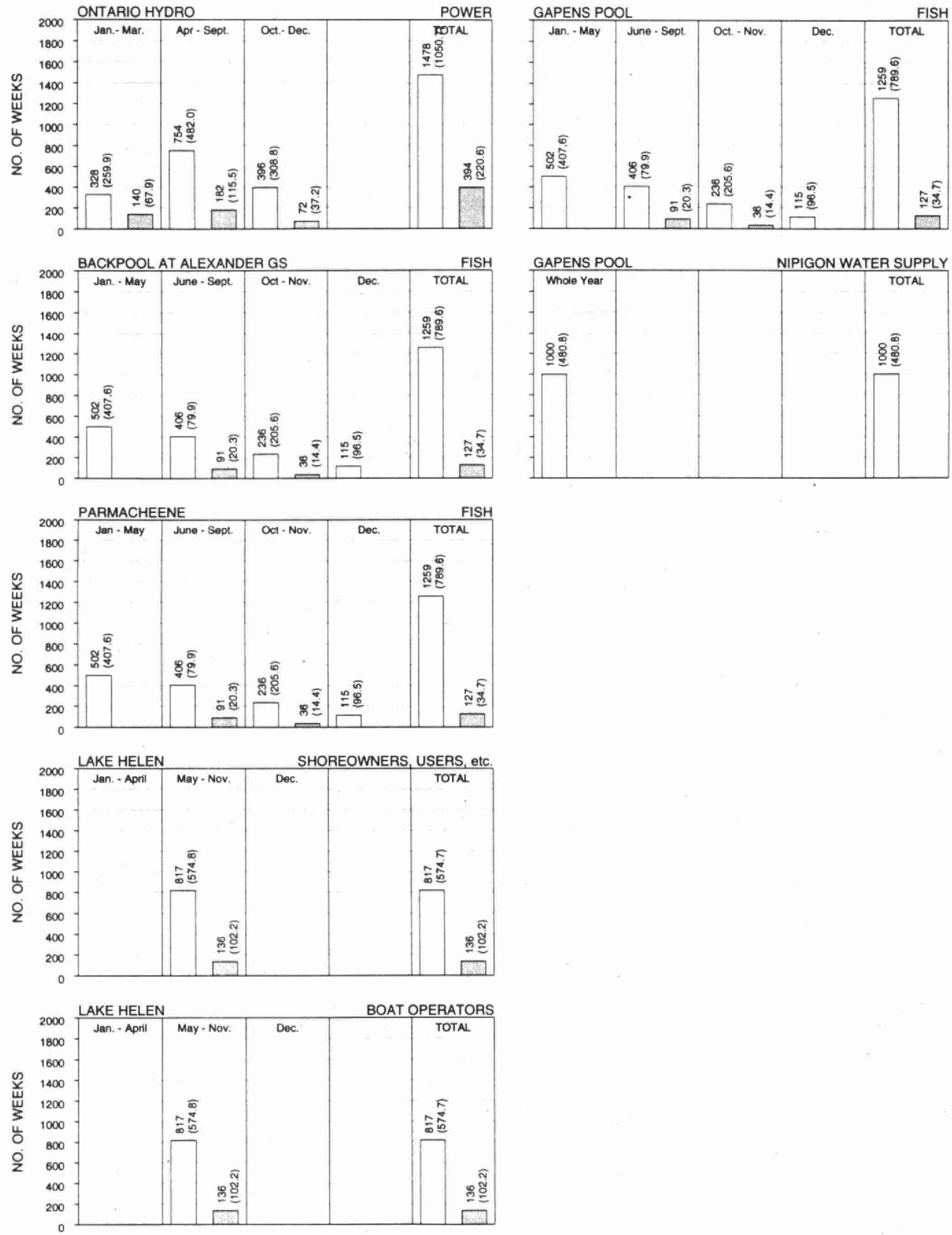
OBS110.SIM

CASE: WEEKLY MEASURED DATA

TOTAL 1872 WEEKS

☐ MINIMUM FLOW BELOW THE EXPECTED RANGE

▩ MINIMUM FLOW ABOVE THE EXPECTED RANGE



OBS110.SIM
CASE: WEEKLY MEASURED DATA

INCREMENTAL CHANGE

FROM:	0	45	260.24	TO:	1	15	259.65	0.59
FROM:	1	39	260.01	TO:	2	14	259.36	0.65
FROM:	2	39	260.19	TO:	3	15	259.58	0.61
FROM:	3	41	260.25	TO:	4	14	259.58	0.67
FROM:	4	40	259.95	TO:	5	17	259.43	0.52
FROM:	5	39	260.05	TO:	6	14	259.48	0.57
FROM:	6	39	260.18	TO:	7	14	259.58	0.60
FROM:	7	42	260.28	TO:	8	16	259.52	0.76
FROM:	8	40	260.18	TO:	9	15	259.54	0.64
FROM:	9	39	259.72	TO:	10	14	259.22	0.50
FROM:	10	40	259.97	TO:	11	17	259.34	0.63
FROM:	11	39	260.11	TO:	12	15	259.53	0.58
FROM:	12	39	260.22	TO:	13	15	259.45	0.77
FROM:	13	40	260.39	TO:	14	16	259.47	0.92
FROM:	14	42	259.77	TO:	15	14	259.52	0.25
FROM:	15	40	259.99	TO:	16	14	259.25	0.74
FROM:	16	39	259.81	TO:	17	14	259.27	0.54
FROM:	17	39	260.28	TO:	18	15	259.62	0.66
FROM:	18	40	260.29	TO:	19	16	259.50	0.79
FROM:	19	44	260.53	TO:	20	15	259.72	0.81
FROM:	20	46	260.11	TO:	21	16	259.51	0.60
FROM:	21	39	259.43	TO:	22	14	258.96	0.47
FROM:	22	43	259.85	TO:	23	16	259.75	0.10
FROM:	23	45	260.34	TO:	24	16	259.66	0.68
FROM:	24	39	259.91	TO:	25	14	259.25	0.66
FROM:	25	39	259.40	TO:	26	11	258.61	0.79
FROM:	26	44	259.99	TO:	27	16	259.42	0.57
FROM:	27	39	260.30	TO:	28	15	259.49	0.81
FROM:	28	39	259.95	TO:	29	15	259.36	0.59
FROM:	29	44	259.51	TO:	30	14	259.20	0.31
FROM:	30	39	259.29	TO:	31	9	259.01	0.28
FROM:	31	41	259.83	TO:	32	16	259.40	0.43
FROM:	32	41	259.91	TO:	33	14	259.38	0.53
FROM:	33	39	259.97	TO:	34	15	259.38	0.59
FROM:	34	40	260.33	TO:	35	14	259.54	0.79

ANNUAL DRAWDOWN (M):
AVERAGE = 0.60
ST.DEV. = 0.17
MAXIMUM = 0.92
MINIMUM = 0.10

MAXIMUM ELEVATION IN FALL (M):
AVERAGE = 260.02
ST.DEV. = 0.29
MAXIMUM = 260.53
MINIMUM = 259.29

MINIMUM ELEVATION IN SPRING (M):
AVERAGE = 259.42
ST.DEV. = 0.23
MAXIMUM = 259.75
MINIMUM = 258.61

MINIMUM OFF PEAK FLOWS
FOR WEEK 23-39 Q= 170.00
THE REST Q= 110.00

		NO. OF WEEKS
NO PEAKING	=	322
PEAKING	=	1545
QON-QOFF > 100 CMS	=	1287
QON-QOFF > 200 CMS	=	860
QON-QOFF > 300 CMS	=	189

**** FOR POWER CALCULATION ****
MINIMUM OFF PEAK FLOWS
FOR WEEK 23-39 Q= 170.00
THE REST Q= 110.00

		MWh	DOLLARS
ON PEAK	=	52011970.	948234400.
OFF PEAK	=	10374740.	127223600.

ANNUAL AVERAGE

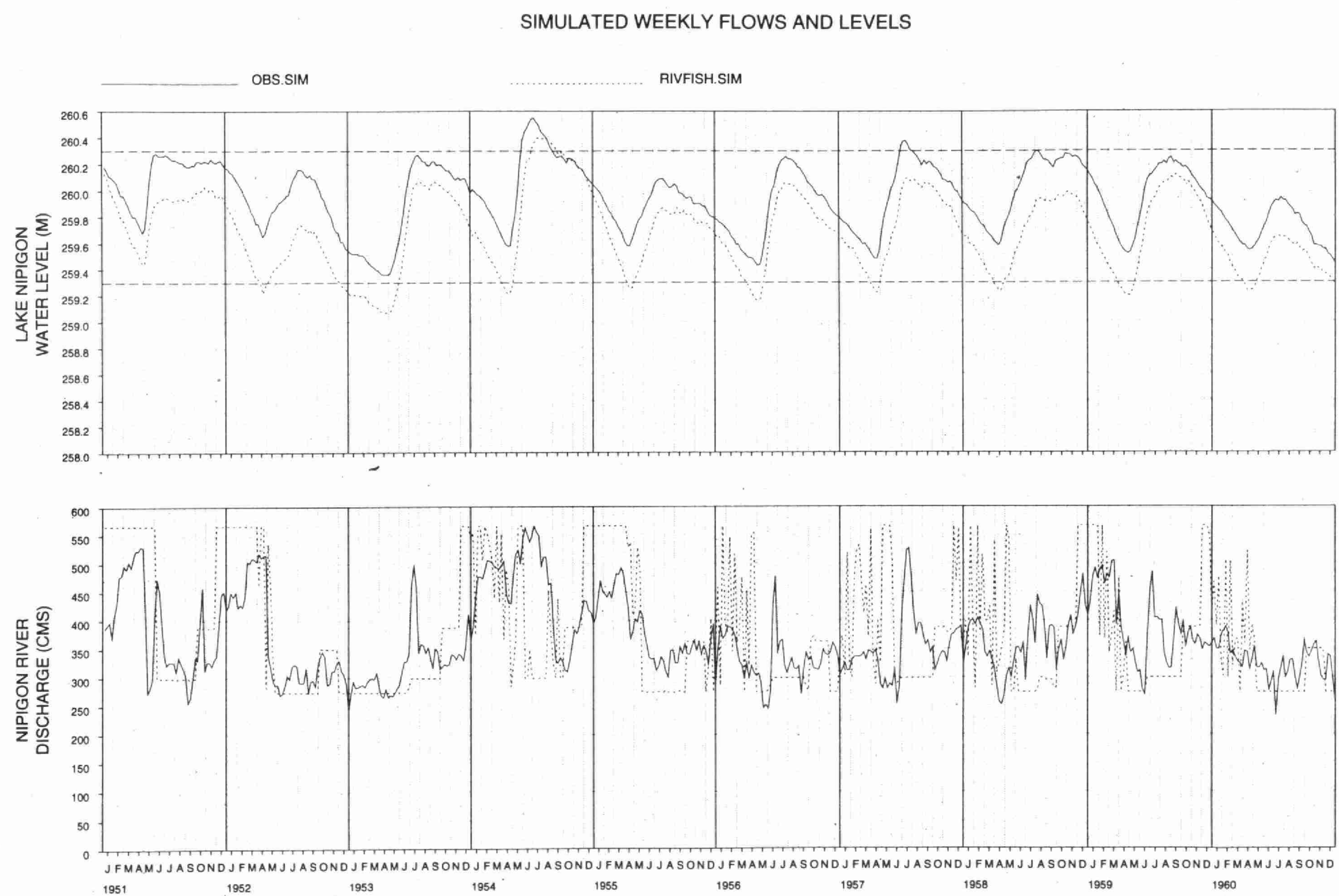
		MWh	DOLLARS
ON PEAK	=	1444777.	26339850.
OFF PEAK	=	288187.	3533989.
		1977	1981-82
ON PEAK	=	8827743.	12219370.
OFF PEAK	=	1155064.	3021642.

ANNUAL POWER

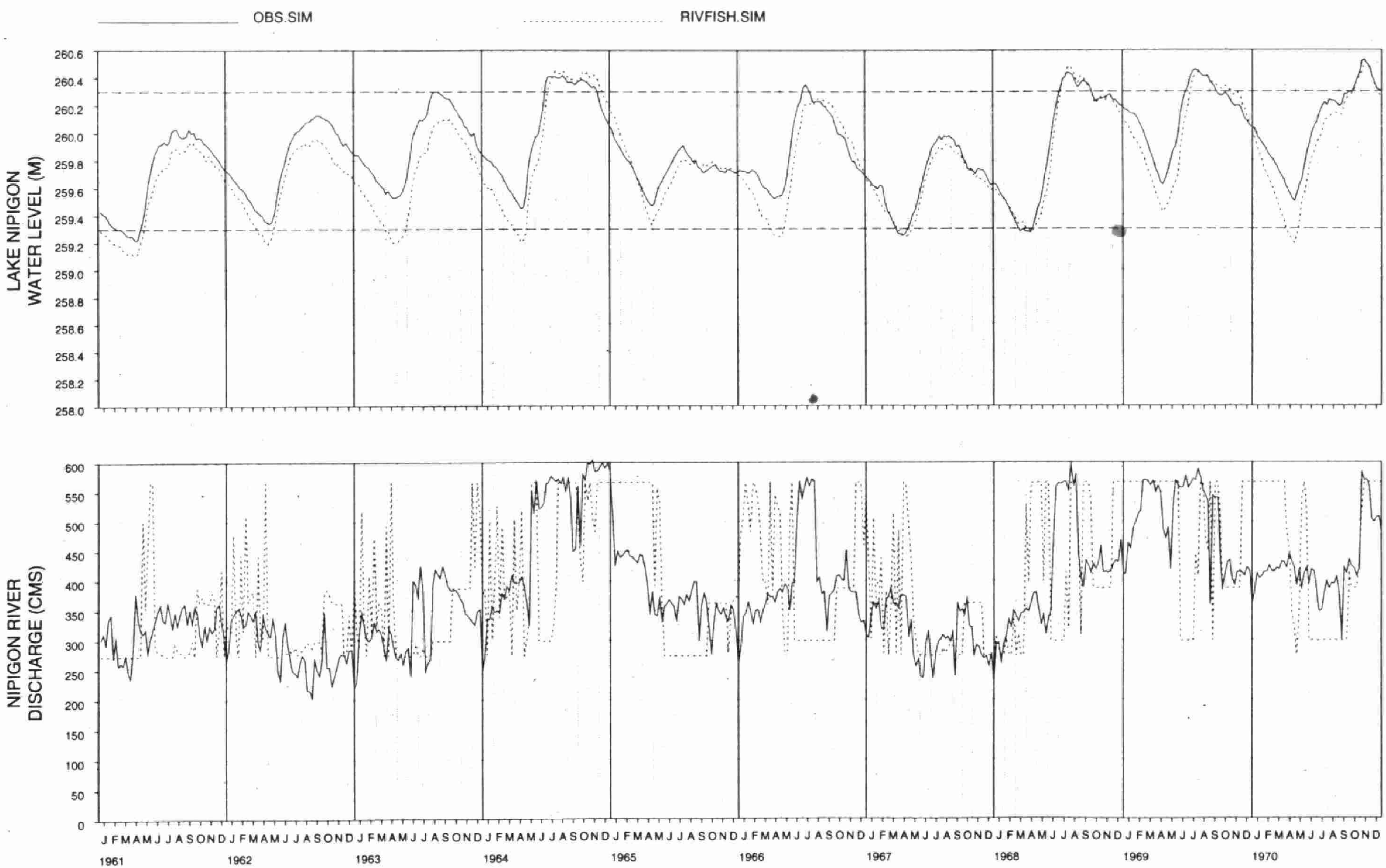
YEAR	ON PEAK MWH	OFF PEAK MWH	TOTAL MWH	ON PEAK $	OFF PEAK $	TOTAL $
1951	1598955.	254732.	1853687.	29178300.	3153208.	32331510.
1952	1534256.	223706.	1757962.	28223110.	2749704.	30972820.
1953	1404123.	234987.	1639109.	25408250.	2928359.	28336610.
1954	1821574.	203831.	2025405.	33141540.	2726734.	35868270.
1955	1549245.	303394.	1852639.	28637710.	3456554.	32094260.
1956	1386792.	288214.	1675006.	25224060.	3674155.	28898220.
1957	1445847.	280349.	1726196.	26159990.	3522031.	29682020.
1958	1438007.	379421.	1817428.	26185400.	4815950.	31001350.
1959	1582871.	295176.	1878047.	29266690.	3387403.	32654100.
1960	1364364.	279900.	1644265.	24867420.	3504777.	28372200.
1961	1351006.	251027.	1602034.	24464290.	3017907.	27482200.
1962	1231502.	248026.	1479529.	22520380.	3033596.	25553980.
1963	1347500.	331645.	1679145.	24518890.	3872107.	28391000.
1964	1869844.	149092.	2018936.	33463980.	2089023.	35553000.
1965	1532770.	317789.	1850559.	28322170.	3746446.	32068620.
1966	1540316.	336509.	1876825.	27684570.	4124004.	31808570.
1967	1317787.	285178.	1602965.	24084230.	3543523.	27627750.
1968	1588204.	318105.	1906309.	28559770.	4023094.	32582870.
1969	1914528.	182574.	2097102.	34844420.	2428519.	37272940.
1970	1556431.	479882.	2036313.	28249480.	5786399.	34035880.
1971	1846152.	248341.	2094493.	33646470.	3032763.	36679230.
1972	1646543.	355447.	2001990.	30475250.	3738741.	34214000.
1973	1085003.	232503.	1317506.	19850540.	2783621.	22634160.
1974	1572939.	240210.	1813149.	27994400.	3114692.	31109090.
1975	1559883.	400667.	1960549.	28516320.	4682708.	33199030.
1976	1416230.	303875.	1720106.	25727630.	3728721.	29456360.
1977	1004911.	308739.	1313650.	18427740.	3690137.	22117880.
1978	1246934.	338785.	1585719.	22930550.	4393242.	27323790.
1979	1361382.	348727.	1710110.	24837590.	4511583.	29349170.
1980	1288189.	260548.	1548737.	23753170.	3260897.	27014060.
1981	1085422.	260652.	1346074.	19802980.	3197138.	23000110.
1982	801702.	316742.	1118444.	14336090.	3898930.	18235020.
1983	1179809.	319881.	1499691.	21686480.	4055295.	25741780.
1984	1388244.	320364.	1708608.	25286600.	3951845.	29238450.
1985	1580894.	266421.	1847315.	28758840.	3379379.	32138210.
1986	1571555.	209287.	1780842.	29199030.	2220549.	31419580.

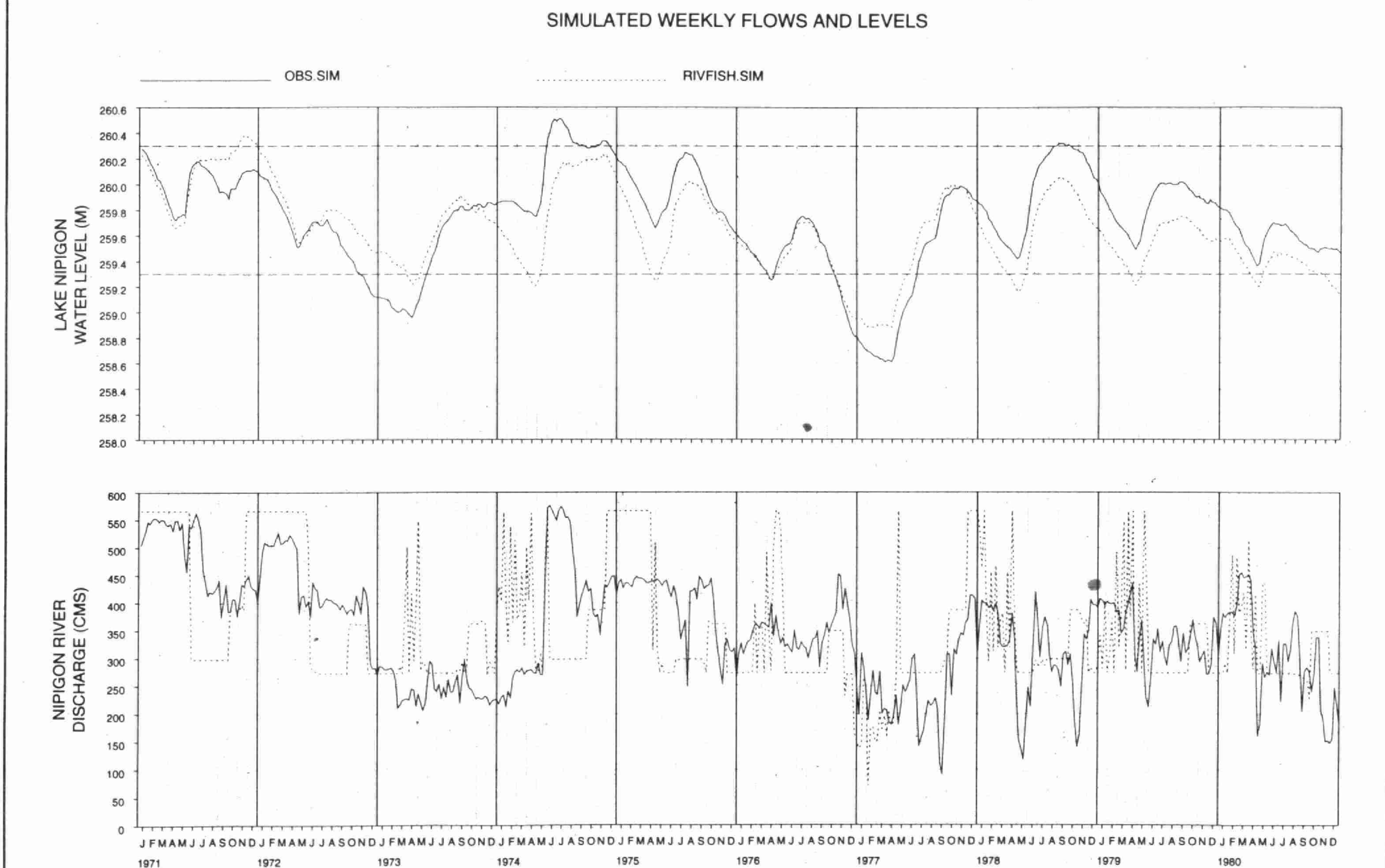
Option RIVFISH

- Time series of simulated average weekly Lake Nipigon water levels and Nipigon River flows (1951-86)
- Performance of average Lake Nipigon level and Nipigon River flow and minimum and maximum flows relative to penalty functions
- Lake Nipigon water level data: fall to spring drawdown; maximum fall; minimum spring; peaking data
- Power produced and dollar value

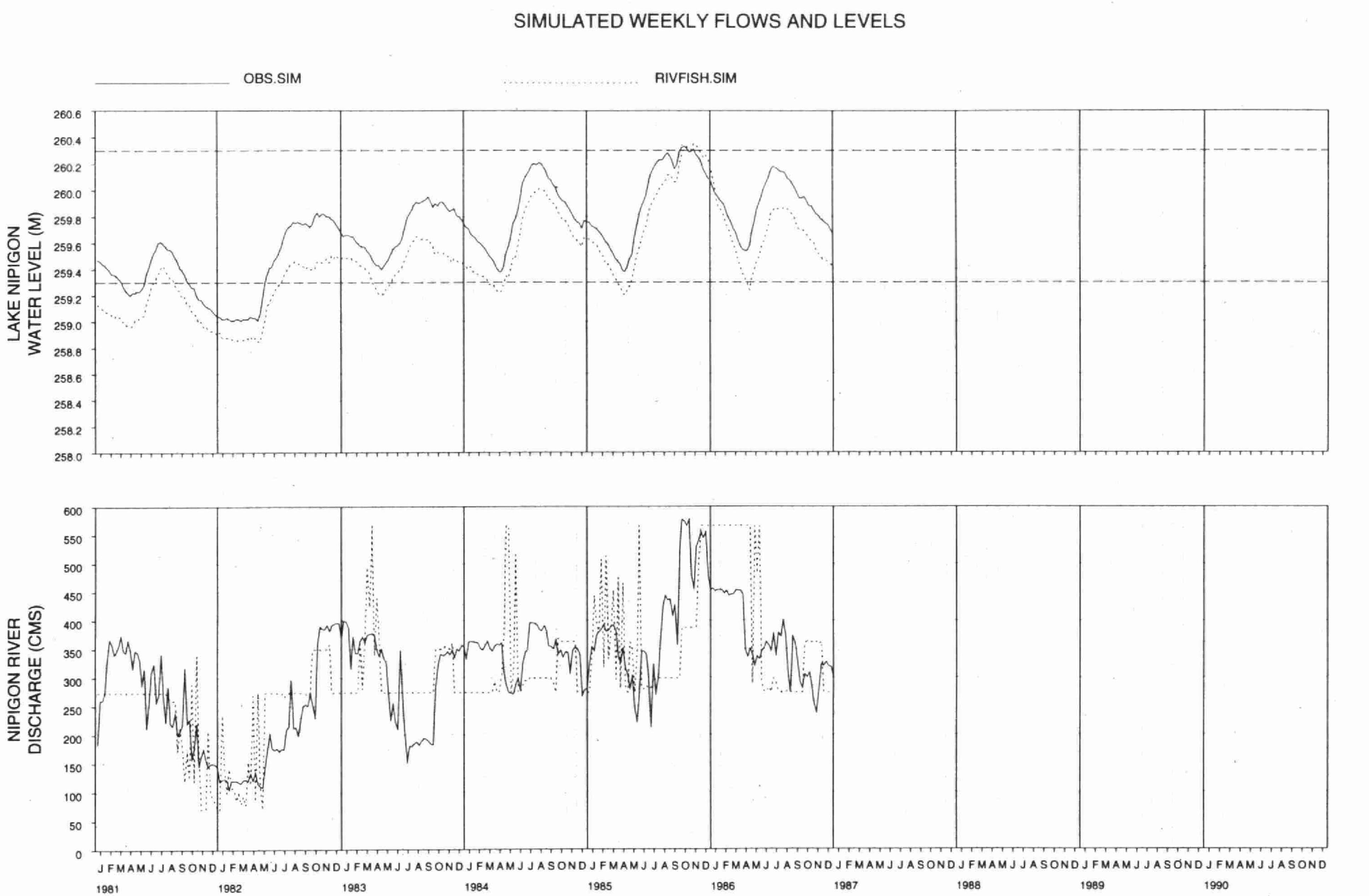

SIMULATED WEEKLY FLOWS AND LEVELS
OBS.SIM
RIVFISH.SIM
LAKE NIPIGON WATER LEVEL (M)
260.6
260.4
260.2
260.0
259.8
259.6
259.4
259.2
259.0
258.8
258.6
258.4
258.2
258.0
NIPIGON RIVER DISCHARGE (CMS)
600
550
500
450
400
350
300
250
200
150
100
50
0
J F M A M J J A S O N D
1951
1952
1953
1954
1955
1956
1957
1958
1959
1960

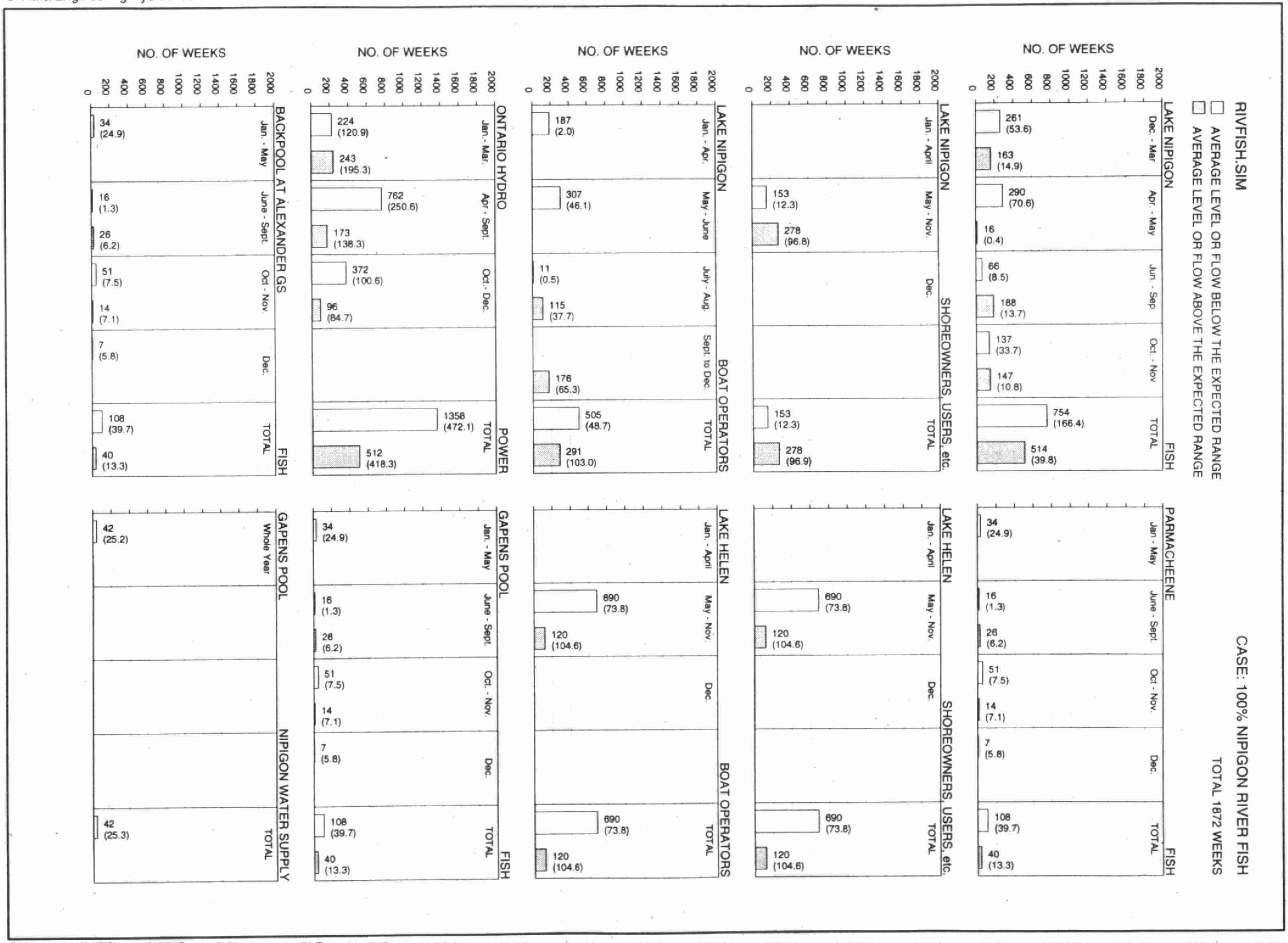
SIMULATED WEEKLY FLOWS AND LEVELS





SIMULATED WEEKLY FLOWS AND LEVELS
OBS.SIM
RIVFISH.SIM
LAKE NIPIGON WATER LEVEL (M)
260.6
260.4
260.2
260.0
259.8
259.6
259.4
259.2
259.0
258.8
258.6
258.4
258.2
258.0
NIPIGON RIVER DISCHARGE (CMS)
600
550
500
450
400
350
300
250
200
150
100
50
0
J F M A M J J A S O N D
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980


SIMULATED WEEKLY FLOWS AND LEVELS
OBS.SIM
RIVFISH.SIM
LAKE NIPIGON WATER LEVEL (M)
260.6
260.4
260.2
260.0
259.8
259.6
259.4
259.2
259.0
258.8
258.6
258.4
258.2
258.0
NIPIGON RIVER DISCHARGE (CMS)
600
550
500
450
400
350
300
250
200
150
100
50
0
J F M A M J J A S O N D
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990


RIVFISH.SIM
AVERAGE LEVEL OR FLOW BELOW THE EXPECTED RANGE
AVERAGE LEVEL OR FLOW ABOVE THE EXPECTED RANGE
CASE: 100% NIPIGON RIVER FISH
TOTAL 1872 WEEKS
NO. OF WEEKS
LAKE NIPIGON FISH
LAKE NIPIGON SHOREOWNERS, USERS, etc.
LAKE NIPIGON BOAT OPERATORS
ONTARIO HYDRO POWER
BACKPOOL AT ALEXANDER GS FISH
PARMACHEENE FISH
LAKE HELEN SHOREOWNERS, USERS, etc.
LAKE HELEN BOAT OPERATORS
GAPENS POOL FISH
GAPENS POOL NIPIGON WATER SUPPLY

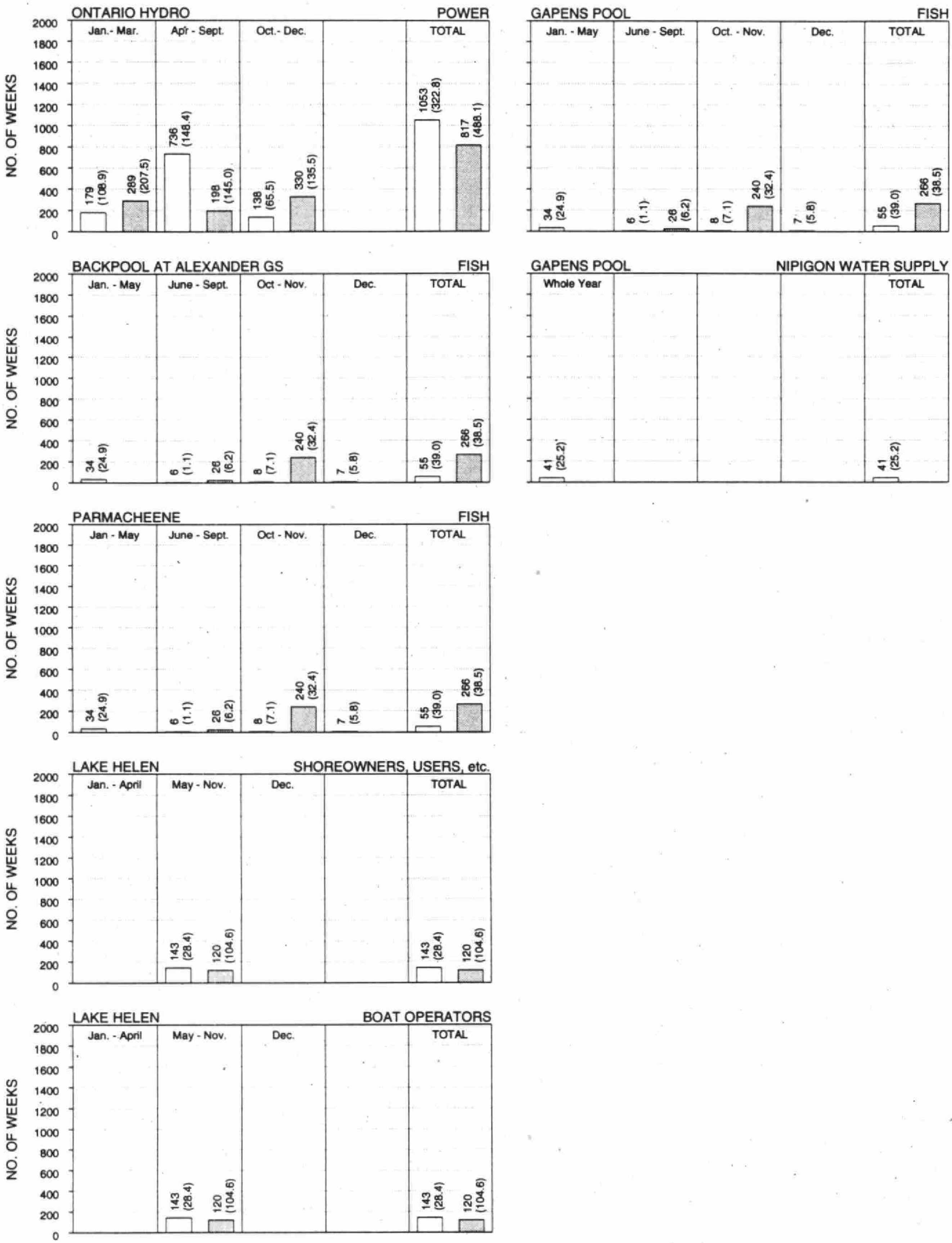
RIVFISH.SIM

CASE: 100% NIPIGON RIVER FISH

TOTAL 1872 WEEKS

☐ MAXIMUM FLOW BELOW THE EXPECTED RANGE

▒ MAXIMUM FLOW ABOVE THE EXPECTED RANGE

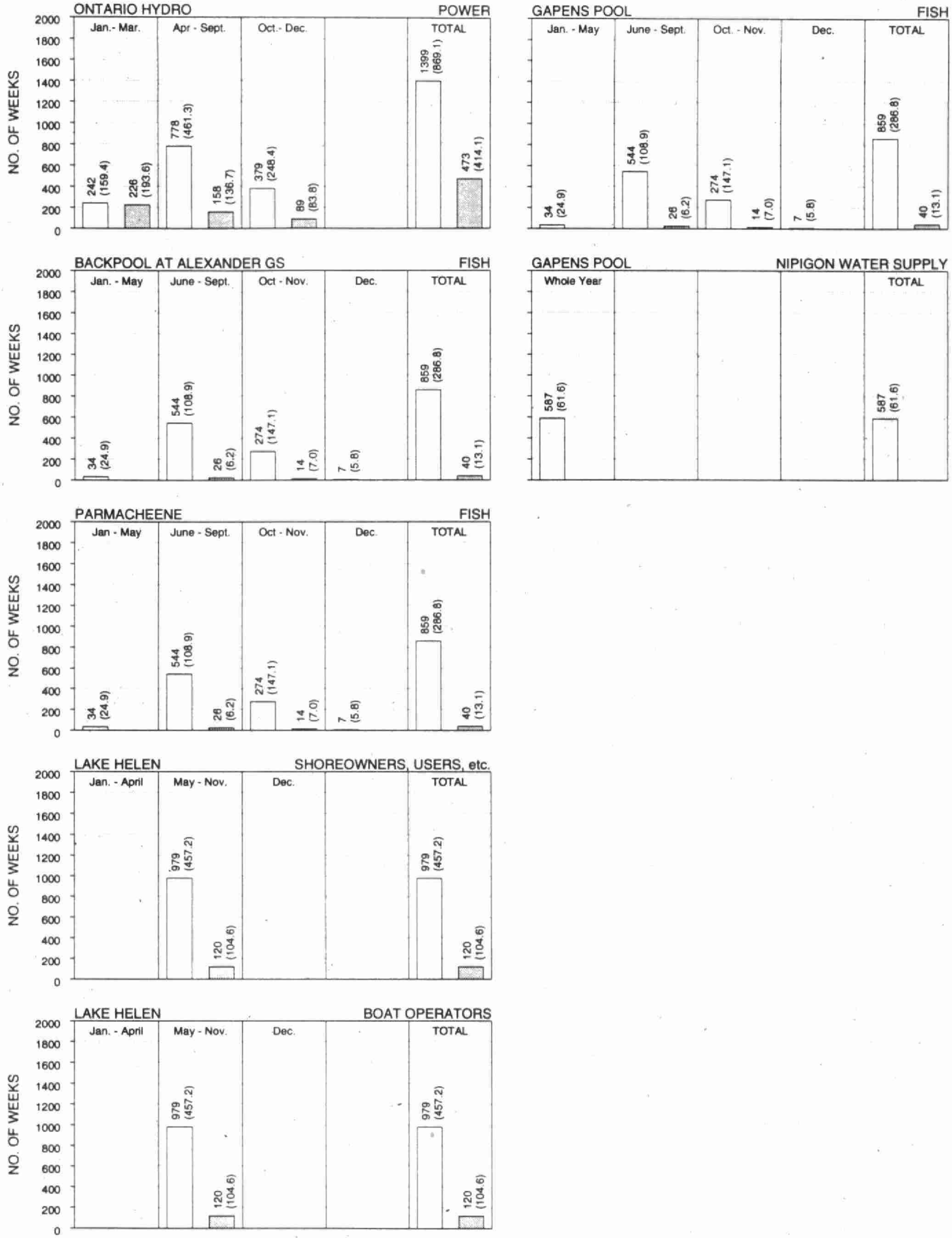


RIVFISH.SIM

CASE: 100% NIPIGON RIVER FISH

TOTAL 1872 WEEKS

☐ MINIMUM FLOW BELOW THE EXPECTED RANGE
▨ MINIMUM FLOW ABOVE THE EXPECTED RANGE



RIVFISH.SIM
CASE: 100% NIPIGON RIVER FISH

INCREMENTAL CHANGE

FROM:	0	42	260.03	TO:	1	15	259.22	0.81
FROM:	1	39	259.61	TO:	2	15	259.07	0.54
FROM:	2	39	260.04	TO:	3	15	259.21	0.83
FROM:	3	39	260.27	TO:	4	15	259.25	1.02
FROM:	4	39	259.82	TO:	5	17	259.16	0.66
FROM:	5	39	259.89	TO:	6	15	259.22	0.67
FROM:	6	39	260.02	TO:	7	15	259.23	0.79
FROM:	7	43	259.99	TO:	8	15	259.20	0.79
FROM:	8	39	260.08	TO:	9	14	259.23	0.85
FROM:	9	39	259.52	TO:	10	14	259.11	0.41
FROM:	10	39	259.89	TO:	11	16	259.19	0.70
FROM:	11	39	259.92	TO:	12	15	259.20	0.72
FROM:	12	39	260.08	TO:	13	15	259.20	0.88
FROM:	13	40	260.44	TO:	14	16	259.33	1.11
FROM:	14	41	259.79	TO:	15	15	259.24	0.55
FROM:	15	39	260.15	TO:	16	15	259.24	0.91
FROM:	16	39	259.79	TO:	17	14	259.28	0.51
FROM:	17	46	260.27	TO:	18	15	259.42	0.85
FROM:	18	40	260.34	TO:	19	16	259.19	1.15
FROM:	19	44	260.51	TO:	20	14	259.66	0.85
FROM:	20	45	260.39	TO:	21	16	259.55	0.84
FROM:	21	39	259.72	TO:	22	14	259.22	0.50
FROM:	22	39	259.84	TO:	23	15	259.21	0.63
FROM:	23	45	260.24	TO:	24	16	259.25	0.99
FROM:	24	39	259.85	TO:	25	13	259.26	0.59
FROM:	25	39	259.41	TO:	26	14	258.88	0.53
FROM:	26	40	260.00	TO:	27	17	259.16	0.84
FROM:	27	39	260.00	TO:	28	15	259.21	0.79
FROM:	28	39	259.71	TO:	29	16	259.20	0.51
FROM:	29	39	259.32	TO:	30	14	258.96	0.36
FROM:	30	39	259.13	TO:	31	16	258.85	0.28
FROM:	31	45	259.48	TO:	32	15	259.21	0.27
FROM:	32	40	259.53	TO:	33	14	259.22	0.31
FROM:	33	39	259.84	TO:	34	15	259.20	0.64
FROM:	34	44	260.35	TO:	35	16	259.24	1.11

ANNUAL DRAWDOWN (M):
AVERAGE = 0.71
ST.DEV. = 0.24
MAXIMUM = 1.15
MINIMUM = 0.27

MAXIMUM ELEVATION IN FALL (M):
AVERAGE = 259.92
ST.DEV. = 0.33
MAXIMUM = 260.51
MINIMUM = 259.13

MINIMUM ELEVATION IN SPRING (M):
AVERAGE = 259.21
ST.DEV. = 0.15
MAXIMUM = 259.66
MINIMUM = 258.85

MINIMUM OFF PEAK FLOWS
FOR WEEK 23-39 Q= 170.00
THE REST Q= 270.00

		NO. OF WEEKS
NO PEAKING	=	508
PEAKING	=	1363
QON-QOFF > 100 CMS	=	915
QON-QOFF > 200 CMS	=	22
QON-QOFF > 300 CMS	=	0

**** FOR POWER CALCULATION ****

MINIMUM OFF PEAK FLOWS

FOR WEEK 23-39	Q=	170.00
THE REST	Q=	270.00

		MWh	DOLLARS
ON PEAK	=	50628730.	925770000.
OFF PEAK	=	11699670.	142955300.

ANNUAL AVERAGE

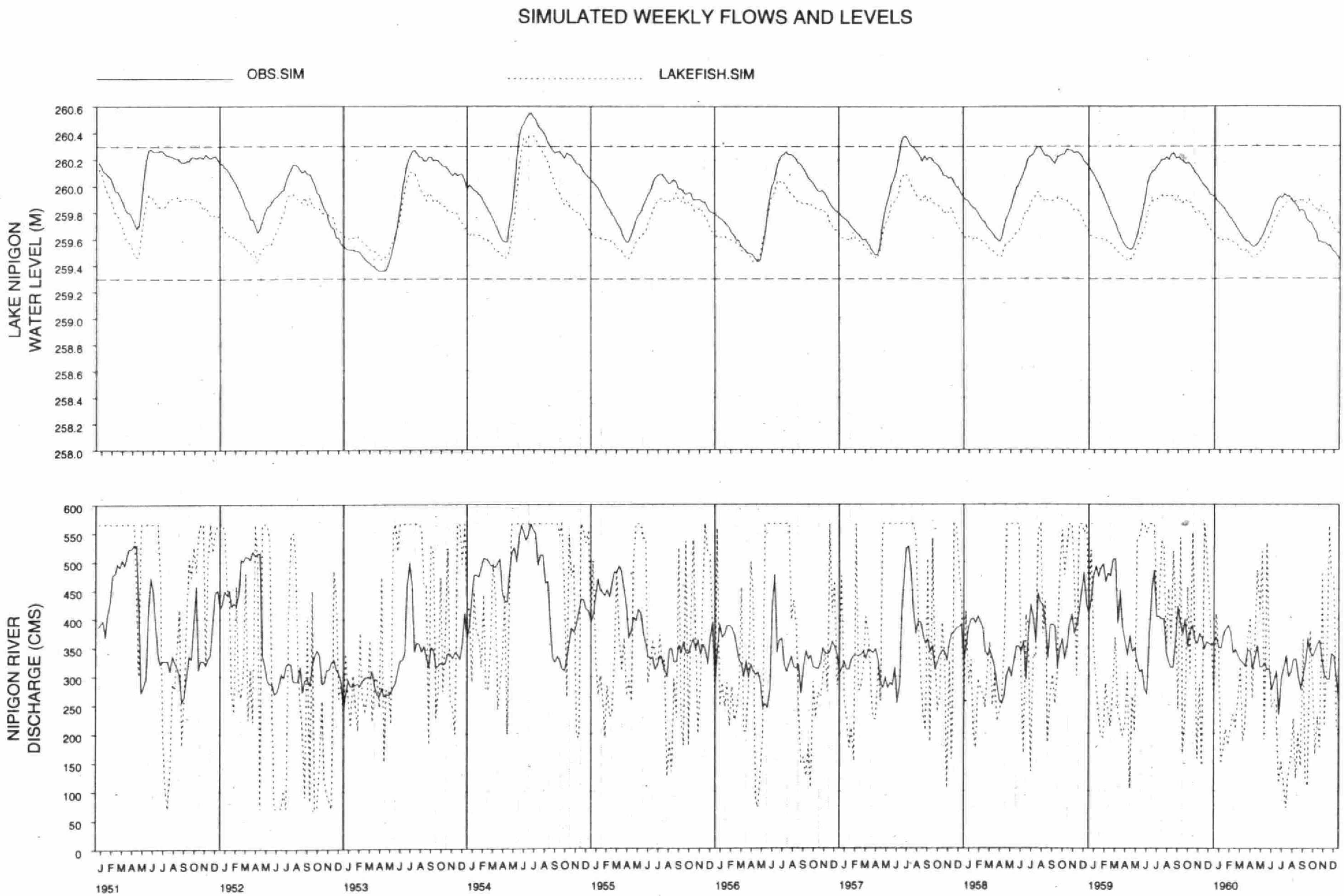
		MWh	DOLLARS
ON PEAK	=	1406354.	25715830.
OFF PEAK	=	324991.	3970980.
		1977	1981-82
ON PEAK	=	2370016.	7162991.
OFF PEAK	=	4942846.	6439278.

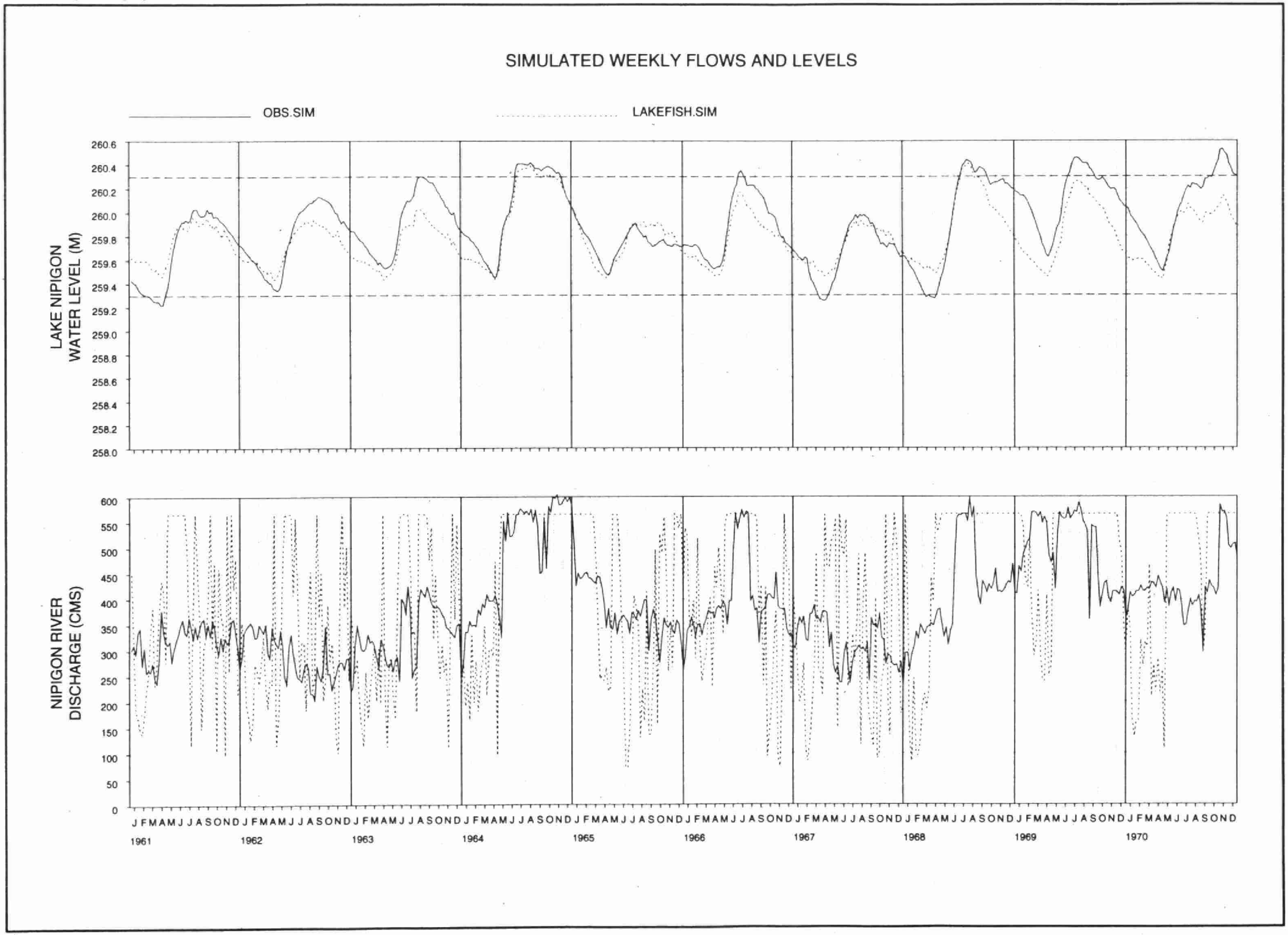
ANNUAL POWER

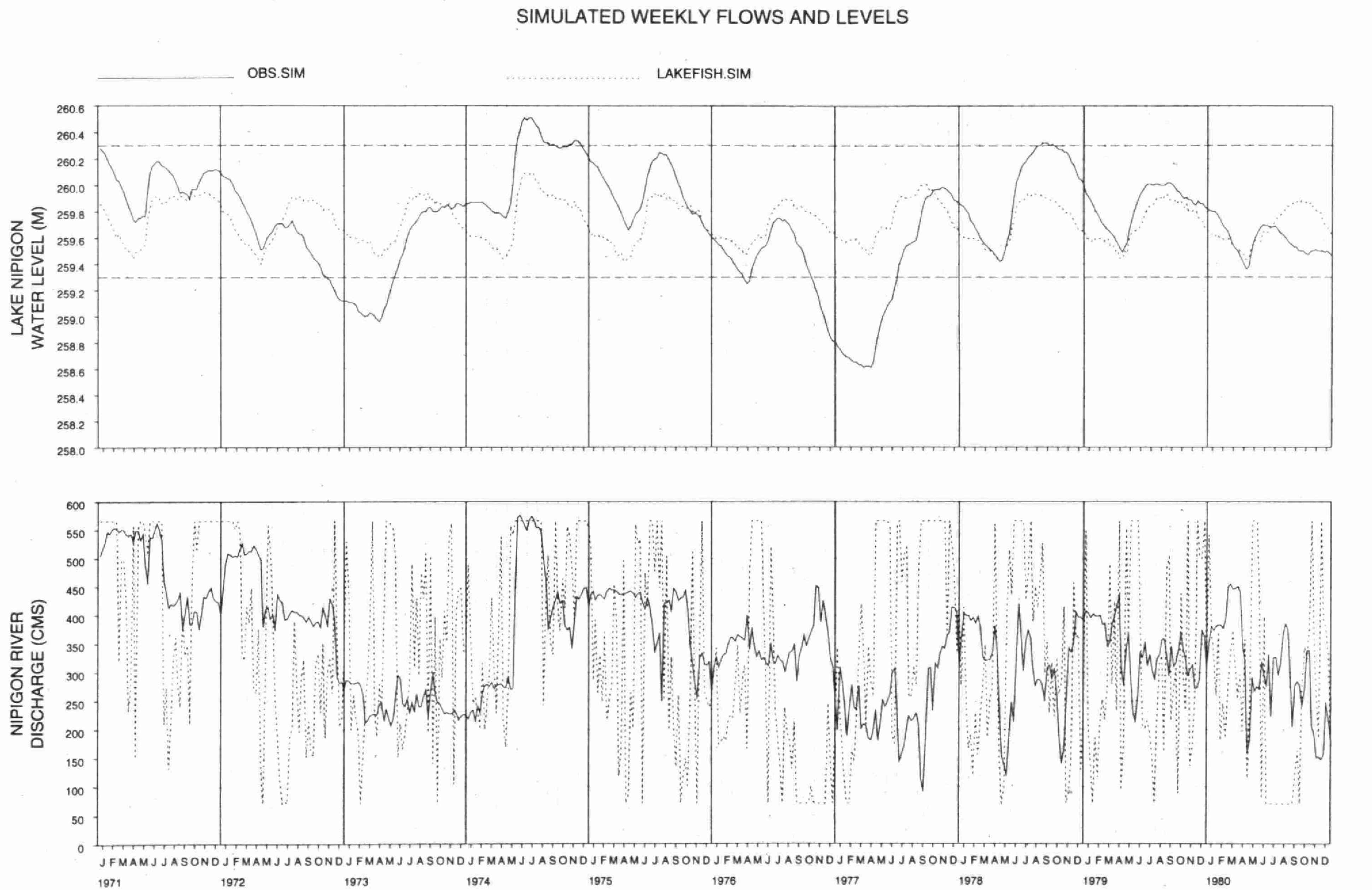
YEAR	ON PEAK MWH	OFF PEAK MWH	TOTAL MWH	ON PEAK $	OFF PEAK $	TOTAL $
1951	1747105.	180690.	1927795.	32161290.	1961387.	34122680.
1952	1507130.	258134.	1765263.	28078270.	2921946.	31000220.
1953	1252594.	385596.	1638191.	22611720.	4726691.	27338420.
1954	1662424.	257725.	1920149.	30651420.	2940494.	33591920.
1955	1528998.	267241.	1796238.	28458170.	3018221.	31476390.
1956	1362432.	353825.	1716257.	25109450.	4319711.	29429160.
1957	1547403.	296079.	1843482.	28273390.	3646110.	31919500.
1958	1455551.	338958.	1794508.	26640680.	4161654.	30802340.
1959	1444350.	336163.	1780514.	26738020.	3923210.	30661230.
1960	1289169.	383796.	1672964.	23732340.	4687653.	28419990.
1961	1224492.	395738.	1620230.	21849780.	5178879.	27028660.
1962	1291837.	384009.	1675846.	23718610.	4761340.	28479950.
1963	1351925.	373212.	1725137.	24721920.	4605210.	29327130.
1964	1742384.	212713.	1955098.	31720990.	2639993.	34360980.
1965	1560250.	250820.	1811070.	28975180.	2846134.	31821310.
1966	1631934.	248509.	1880444.	30100460.	2800958.	32901420.
1967	1317173.	370074.	1687248.	24049970.	4630833.	28680800.
1968	1607011.	273519.	1880530.	28704370.	3609480.	32313850.
1969	1894452.	133810.	2028262.	34887410.	1419828.	36307240.
1970	1736633.	188628.	1925260.	32140920.	1880241.	34021160.
1971	1761297.	172032.	1933329.	32420890.	1846229.	34267120.
1972	1581482.	222016.	1803498.	29212560.	2620930.	31833490.
1973	1187419.	414193.	1601612.	21346340.	5279845.	26626190.
1974	1515337.	319802.	1835139.	27733610.	3880726.	31614340.
1975	1489909.	278417.	1768327.	27868340.	3085954.	30954290.
1976	1168137.	431096.	1599233.	20910380.	5691193.	26601570.
1977	942588.	518475.	1461063.	16112870.	6834380.	22947250.
1978	1341181.	365519.	1706700.	24724480.	4438250.	29162730.
1979	1280823.	376772.	1657595.	23275690.	4789304.	28064990.
1980	1238751.	413373.	1652124.	22686430.	5122755.	27809190.
1981	775332.	453484.	1228817.	14067900.	5721879.	19789780.
1982	758896.	478252.	1237148.	12962810.	6089603.	19052410.
1983	1191210.	415426.	1606635.	21618330.	5230636.	26848970.
1984	1208660.	399601.	1608262.	21602420.	5175305.	26777720.
1985	1488005.	311499.	1799504.	27262030.	3704081.	30966110.
1986	1544096.	240437.	1784533.	28642810.	2763889.	31406700.

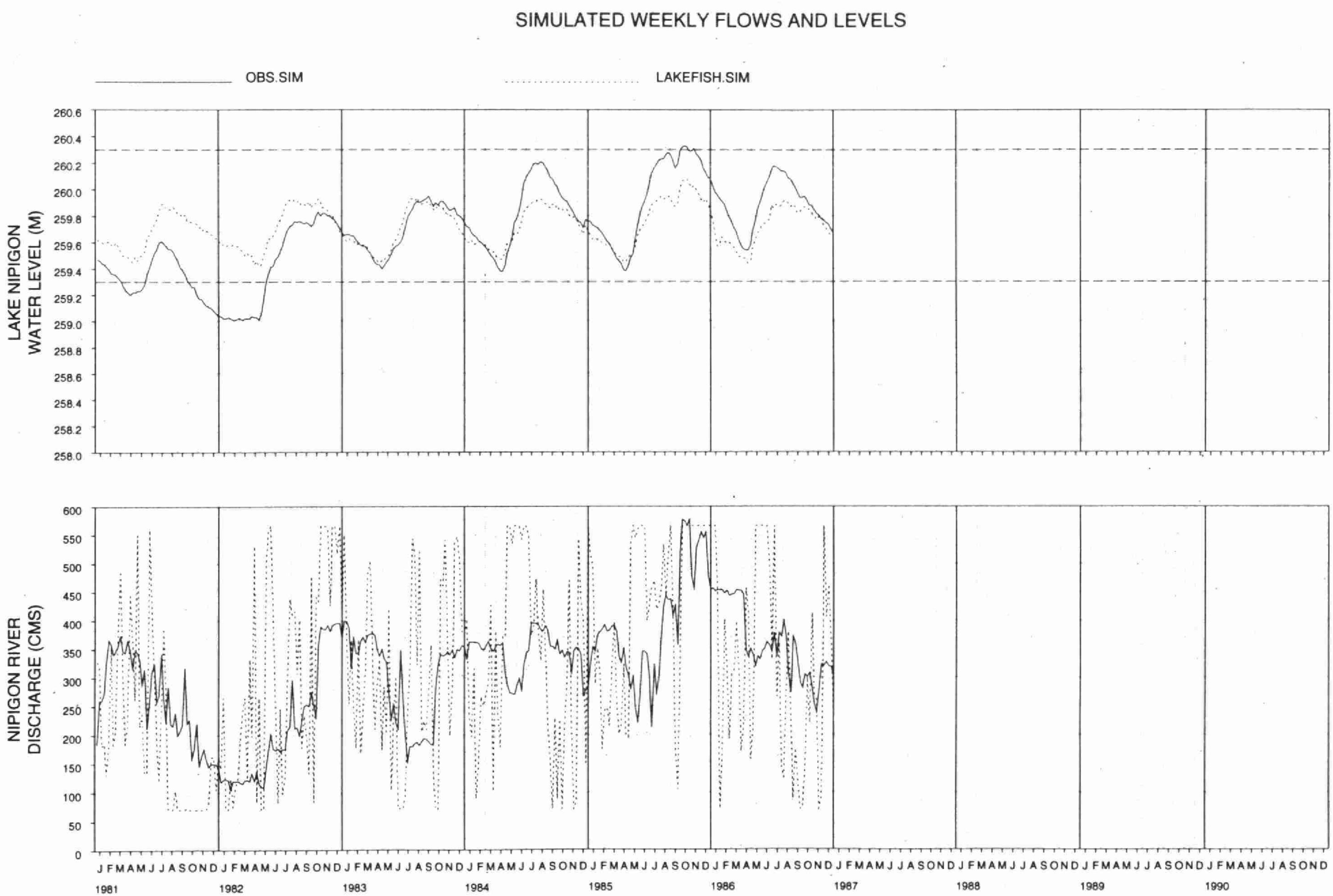
Option LAKEFISH

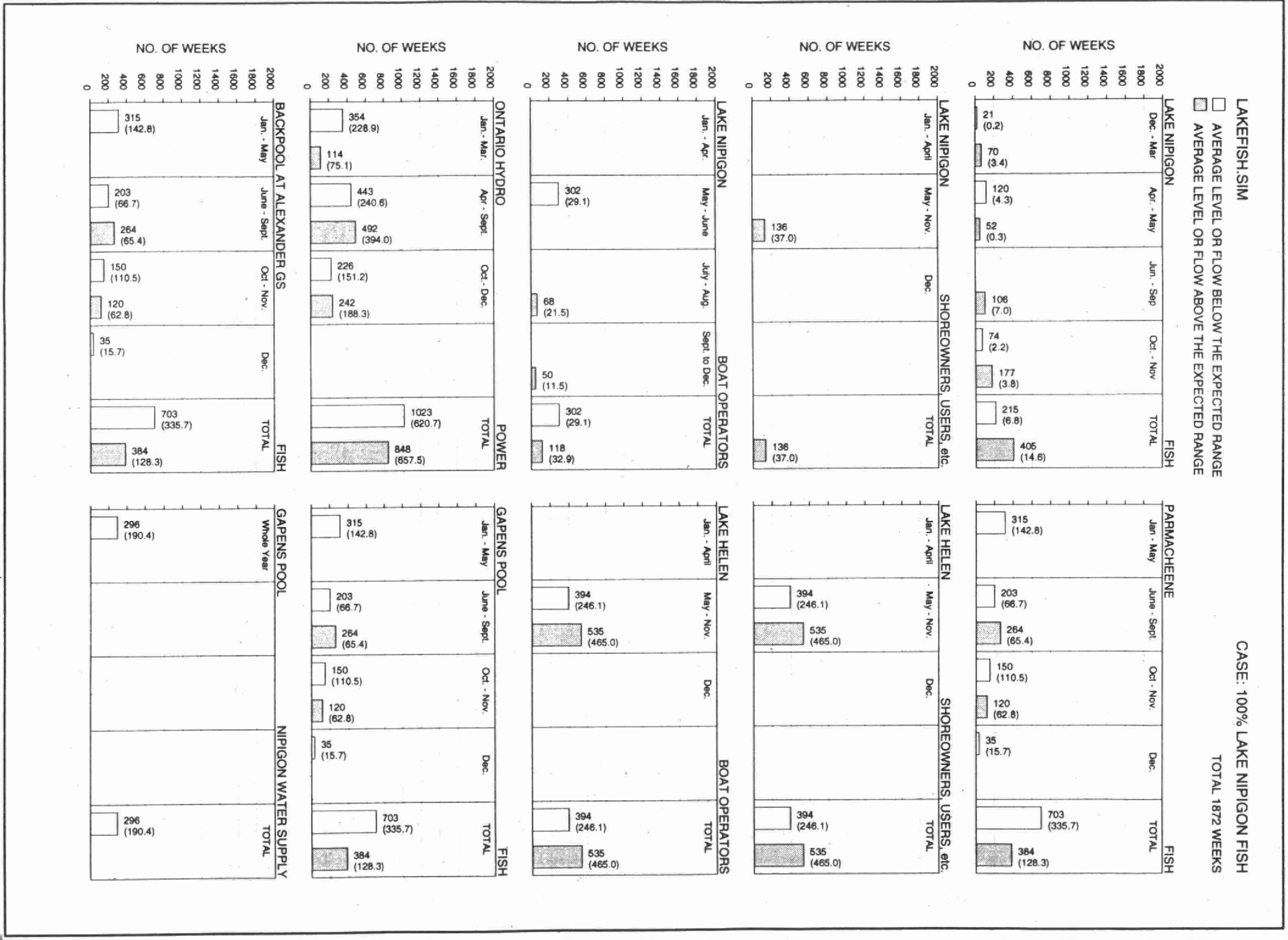
- Time series of simulated average weekly Lake Nipigon water levels and Nipigon River flows (1951-86)
- Performance of average Lake Nipigon level and Nipigon River flow and minimum and maximum flows relative to penalty functions
- Lake Nipigon water level data: fall to spring drawdown; maximum fall; minimum spring; peaking data
- Power produced and dollar value

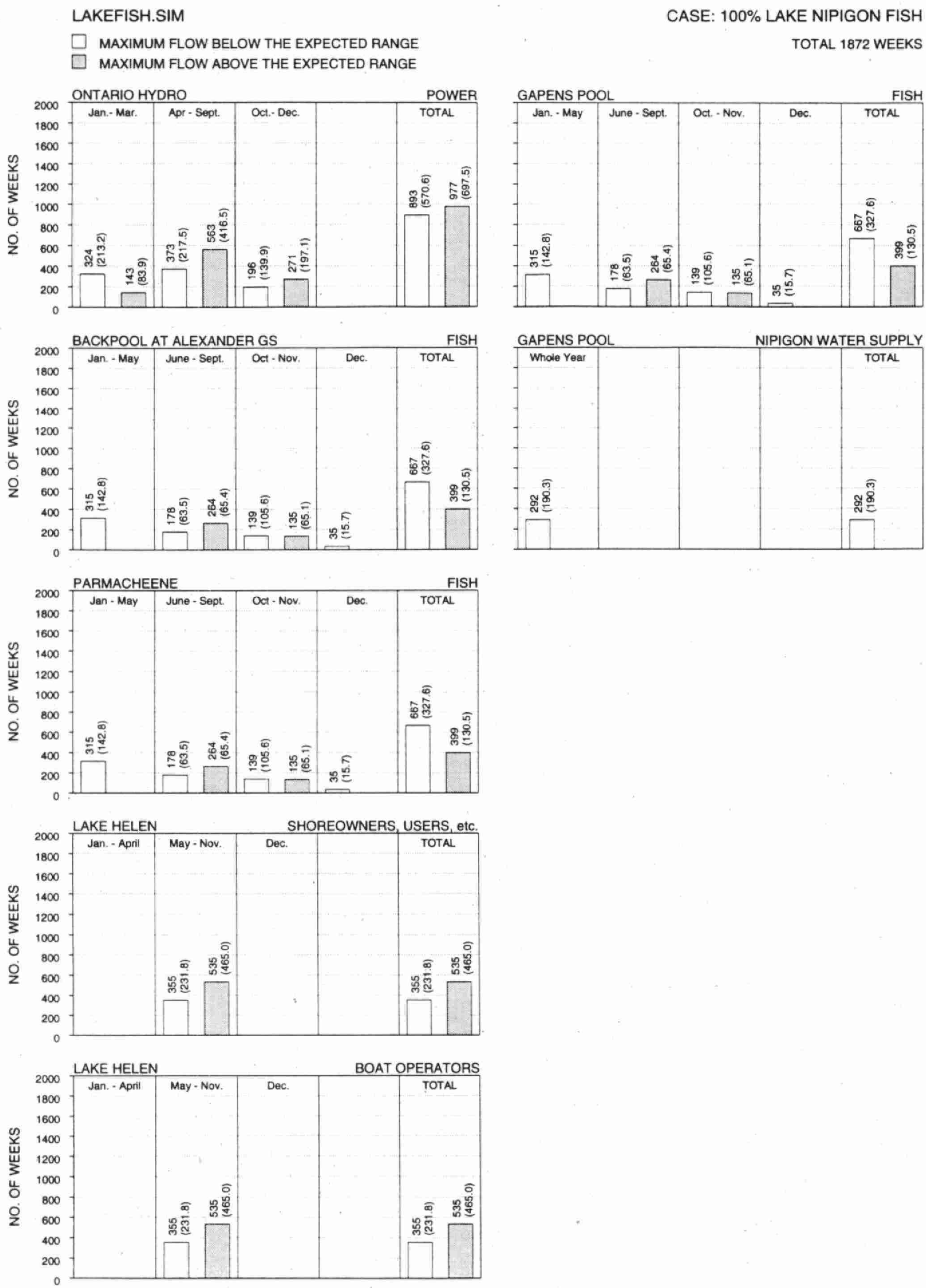

SIMULATED WEEKLY FLOWS AND LEVELS
OBS.SIM
LAKEFISH.SIM
LAKE NIPIGON WATER LEVEL (M)
260.6
260.4
260.2
260.0
259.8
259.6
259.4
259.2
259.0
258.8
258.6
258.4
258.2
258.0
NIPIGON RIVER DISCHARGE (CMS)
600
550
500
450
400
350
300
250
200
150
100
50
0
J F M A M J J A S O N D
1951
1952
1953
1954
1955
1956
1957
1958
1959
1960


SIMULATED WEEKLY FLOWS AND LEVELS
OBS.SIM
LAKEFISH.SIM
LAKE NIPIGON WATER LEVEL (M)
260.6
260.4
260.2
260.0
259.8
259.6
259.4
259.2
259.0
258.8
258.6
258.4
258.2
258.0
NIPIGON RIVER DISCHARGE (CMS)
600
550
500
450
400
350
300
250
200
150
100
50
0
J F M A M J J A S O N D
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970


SIMULATED WEEKLY FLOWS AND LEVELS
OBS.SIM
LAKEFISH.SIM
LAKE NIPIGON WATER LEVEL (M)
260.6
260.4
260.2
260.0
259.8
259.6
259.4
259.2
259.0
258.8
258.6
258.4
258.2
258.0
NIPIGON RIVER DISCHARGE (CMS)
600
550
500
450
400
350
300
250
200
150
100
50
0
J F M A M J J A S O N D
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980


SIMULATED WEEKLY FLOWS AND LEVELS
OBS.SIM
LAKEFISH.SIM
LAKE NIPIGON
WATER LEVEL (M)
260.6
260.4
260.2
260.0
259.8
259.6
259.4
259.2
259.0
258.8
258.6
258.4
258.2
258.0
NIPIGON RIVER
DISCHARGE (CMS)
600
550
500
450
400
350
300
250
200
150
100
50
0
J F M A M J J A S O N D
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990


LAKEFISH.SIM
AVERAGE LEVEL OR FLOW BELOW THE EXPECTED RANGE
AVERAGE LEVEL OR FLOW ABOVE THE EXPECTED RANGE
CASE: 100% LAKE NIPIGON FISH
TOTAL 1872 WEEKS
NO. OF WEEKS
0 200 400 600 800 1000 1200 1400 1600 1800 2000
LAKE NIPIGON FISH
Dec. - Mar 21 (0.2) 70 (3.4)
Apr. - May 120 (4.3) 52 (0.3)
Jun. - Sep 106 (7.0)
Oct. - Nov 74 (2.2) 177 (3.8)
TOTAL 215 (6.8) 405 (14.6)
LAKE NIPIGON SHOREOWNERS, USERS, etc.
Jan. - April
May - Nov. 136 (37.0)
Dec.
TOTAL 136 (37.0)
LAKE NIPIGON BOAT OPERATORS
Jan. - Apr.
May - June 302 (29.1)
July - Aug. 68 (21.5)
Sept. to Dec. 50 (11.5)
TOTAL 302 (29.1) 118 (32.9)
ONTARIO HYDRO POWER
Jan. - Mar. 354 (228.9) 114 (75.1)
Apr. - Sept. 443 (240.6) 492 (394.0)
Oct. - Dec. 226 (151.2) 242 (188.3)
TOTAL 1023 (620.7) 848 (657.5)
BACKPOOL AT ALEXANDER GS FISH
Jan. - May 315 (142.8)
June - Sept. 203 (66.7) 264 (65.4)
Oct. - Nov. 150 (110.5) 120 (62.8)
Dec. 35 (15.7)
TOTAL 703 (335.7) 384 (128.3)
PARMACHEENE FISH
Jan. - May 315 (142.8)
June - Sept. 203 (66.7) 264 (65.4)
Oct. - Nov. 150 (110.5) 120 (62.8)
Dec. 35 (15.7)
TOTAL 703 (335.7) 384 (128.3)
LAKE HELEN SHOREOWNERS, USERS, etc.
Jan. - April
May - Nov. 394 (246.1) 535 (465.0)
Dec.
TOTAL 394 (246.1) 535 (465.0)
LAKE HELEN BOAT OPERATORS
Jan. - April
May - Nov. 394 (246.1) 535 (465.0)
Dec.
TOTAL 394 (246.1) 535 (465.0)
GAPENS POOL FISH
Jan. - May 315 (142.8)
June - Sept. 203 (66.7) 264 (65.4)
Oct. - Nov. 150 (110.5) 120 (62.8)
Dec. 35 (15.7)
TOTAL 703 (335.7) 384 (128.3)
GAPENS POOL NIPIGON WATER SUPPLY
Whole Year 296 (190.4)
TOTAL 296 (190.4)



LAKEFISH.SIM
CASE: 100% LAKE NIPIGON FISH
TOTAL 1872 WEEKS
MAXIMUM FLOW BELOW THE EXPECTED RANGE
MAXIMUM FLOW ABOVE THE EXPECTED RANGE
NO. OF WEEKS
ONTARIO HYDRO
POWER
Jan.- Mar.
Apr - Sept.
Oct.- Dec.
TOTAL
324 (213.2)
143 (83.9)
373 (217.5)
563 (416.5)
196 (139.9)
271 (197.1)
893 (570.6)
977 (697.5)
GAPENS POOL
FISH
Jan. - May
June - Sept.
Oct. - Nov.
Dec.
TOTAL
315 (142.8)
178 (63.5)
264 (65.4)
139 (105.6)
135 (65.1)
35 (15.7)
667 (327.6)
399 (130.5)
BACKPOOL AT ALEXANDER GS
FISH
Jan. - May
June - Sept.
Oct - Nov.
Dec.
TOTAL
315 (142.8)
178 (63.5)
264 (65.4)
139 (105.6)
135 (65.1)
35 (15.7)
667 (327.6)
399 (130.5)
GAPENS POOL
NIPIGON WATER SUPPLY
Whole Year
TOTAL
292 (190.3)
292 (190.3)
PARMACHEENE
FISH
Jan - May
June - Sept.
Oct - Nov.
Dec.
TOTAL
315 (142.8)
178 (63.5)
264 (65.4)
139 (105.6)
135 (65.1)
35 (15.7)
667 (327.6)
399 (130.5)
LAKE HELEN
SHOREOWNERS, USERS, etc.
Jan. - April
May - Nov.
Dec.
TOTAL
355 (231.8)
535 (465.0)
355 (231.8)
535 (465.0)
LAKE HELEN
BOAT OPERATORS
Jan. - April
May - Nov.
Dec.
TOTAL
355 (231.8)
535 (465.0)
355 (231.8)
535 (465.0)
0
200
400
600
800
1000
1200
1400
1600
1800
2000

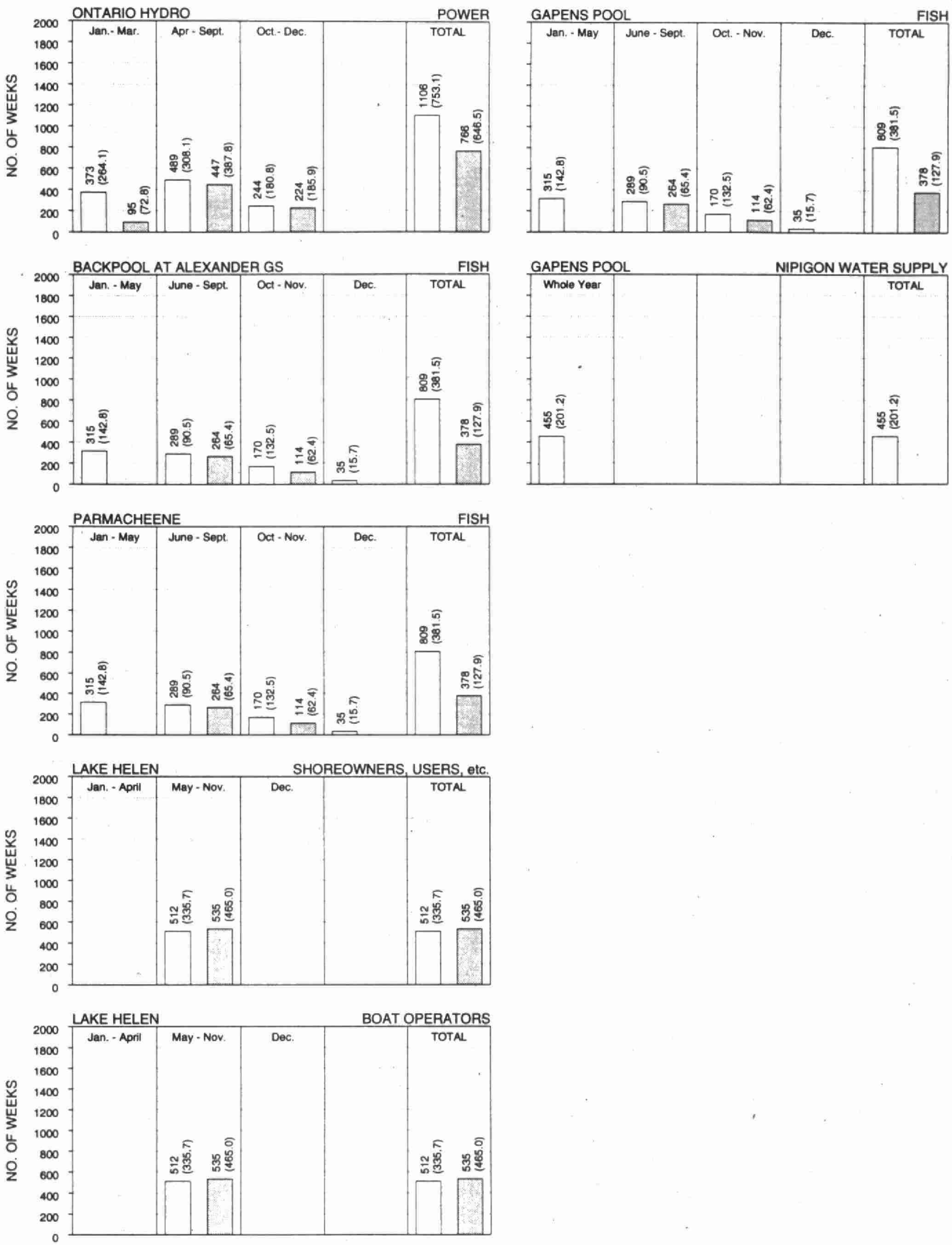
LAKEFISH.SIM

CASE: 100% LAKE NIPIGON FISH

TOTAL 1872 WEEKS

MINIMUM FLOW BELOW THE EXPECTED RANGE

MINIMUM FLOW ABOVE THE EXPECTED RANGE



LAKEFISH.SIM
CASE: 100% LAKE NIPIGON FISH

INCREMENTAL CHANGE

FROM:	0	39	259.91	TO:	1	15	259.42	0.49
FROM:	1	39	259.84	TO:	2	15	259.44	0.40
FROM:	2	39	259.90	TO:	3	15	259.45	0.45
FROM:	3	39	259.90	TO:	4	15	259.45	0.45
FROM:	4	40	259.88	TO:	5	15	259.43	0.45
FROM:	5	39	259.87	TO:	6	15	259.45	0.42
FROM:	6	39	259.87	TO:	7	14	259.46	0.41
FROM:	7	39	259.92	TO:	8	15	259.43	0.49
FROM:	8	39	259.90	TO:	9	14	259.46	0.44
FROM:	9	39	259.87	TO:	10	15	259.46	0.41
FROM:	10	40	259.90	TO:	11	15	259.43	0.47
FROM:	11	39	259.89	TO:	12	15	259.43	0.46
FROM:	12	39	259.87	TO:	13	15	259.43	0.44
FROM:	13	40	260.33	TO:	14	15	259.45	0.88
FROM:	14	39	259.92	TO:	15	14	259.46	0.46
FROM:	15	39	259.86	TO:	16	14	259.46	0.40
FROM:	16	39	259.86	TO:	17	14	259.48	0.38
FROM:	17	39	260.11	TO:	18	14	259.45	0.66
FROM:	18	39	260.05	TO:	19	16	259.43	0.62
FROM:	19	44	260.14	TO:	20	14	259.44	0.70
FROM:	20	39	259.95	TO:	21	16	259.40	0.55
FROM:	21	39	259.88	TO:	22	14	259.45	0.43
FROM:	22	39	259.88	TO:	23	15	259.44	0.44
FROM:	23	39	259.90	TO:	24	14	259.42	0.48
FROM:	24	42	259.85	TO:	25	13	259.47	0.38
FROM:	25	39	259.80	TO:	26	14	259.46	0.34
FROM:	26	40	259.97	TO:	27	16	259.42	0.55
FROM:	27	39	259.88	TO:	28	14	259.44	0.44
FROM:	28	39	259.89	TO:	29	15	259.43	0.46
FROM:	29	39	259.88	TO:	30	15	259.45	0.43
FROM:	30	39	259.76	TO:	31	16	259.42	0.34
FROM:	31	41	259.93	TO:	32	15	259.44	0.49
FROM:	32	40	259.89	TO:	33	14	259.47	0.42
FROM:	33	40	259.85	TO:	34	14	259.45	0.40
FROM:	34	40	260.08	TO:	35	15	259.44	0.64

ANNUAL DRAWDOWN (M):
AVERAGE = 0.48
ST.DEV. = 0.11
MAXIMUM = 0.88
MINIMUM = 0.34

MAXIMUM ELEVATION IN FALL (M):
AVERAGE = 259.92
ST.DEV. = 0.11
MAXIMUM = 260.33
MINIMUM = 259.76

MINIMUM ELEVATION IN SPRING (M):
AVERAGE = 259.44
ST.DEV. = 0.02
MAXIMUM = 259.48
MINIMUM = 259.40

MINIMUM OFF PEAK FLOWS
FOR WEEK 23-39 Q= 170.00
THE REST Q= 270.00

		NO. OF WEEKS
NO PEAKING	=	1305
PEAKING	=	566
QON-QOFF > 100 CMS	=	250
QON-QOFF > 200 CMS	=	59
QON-QOFF > 300 CMS	=	0

**** FOR POWER CALCULATION ****
MINIMUM OFF PEAK FLOWS

FOR WEEK 23-39	Q=	170.00
THE REST	Q=	270.00

		MWh	DOLLARS
ON PEAK	=	43409960.	768227500.
OFF PEAK	=	15074760.	201164500.

ANNUAL AVERAGE

		MWh	DOLLARS
ON PEAK	=	1205832.	21339650.
OFF PEAK	=	418743.	5587903.
		1977	1981-82
ON PEAK	=	7407695.	5369587.
OFF PEAK	=	3454395.	7102931.

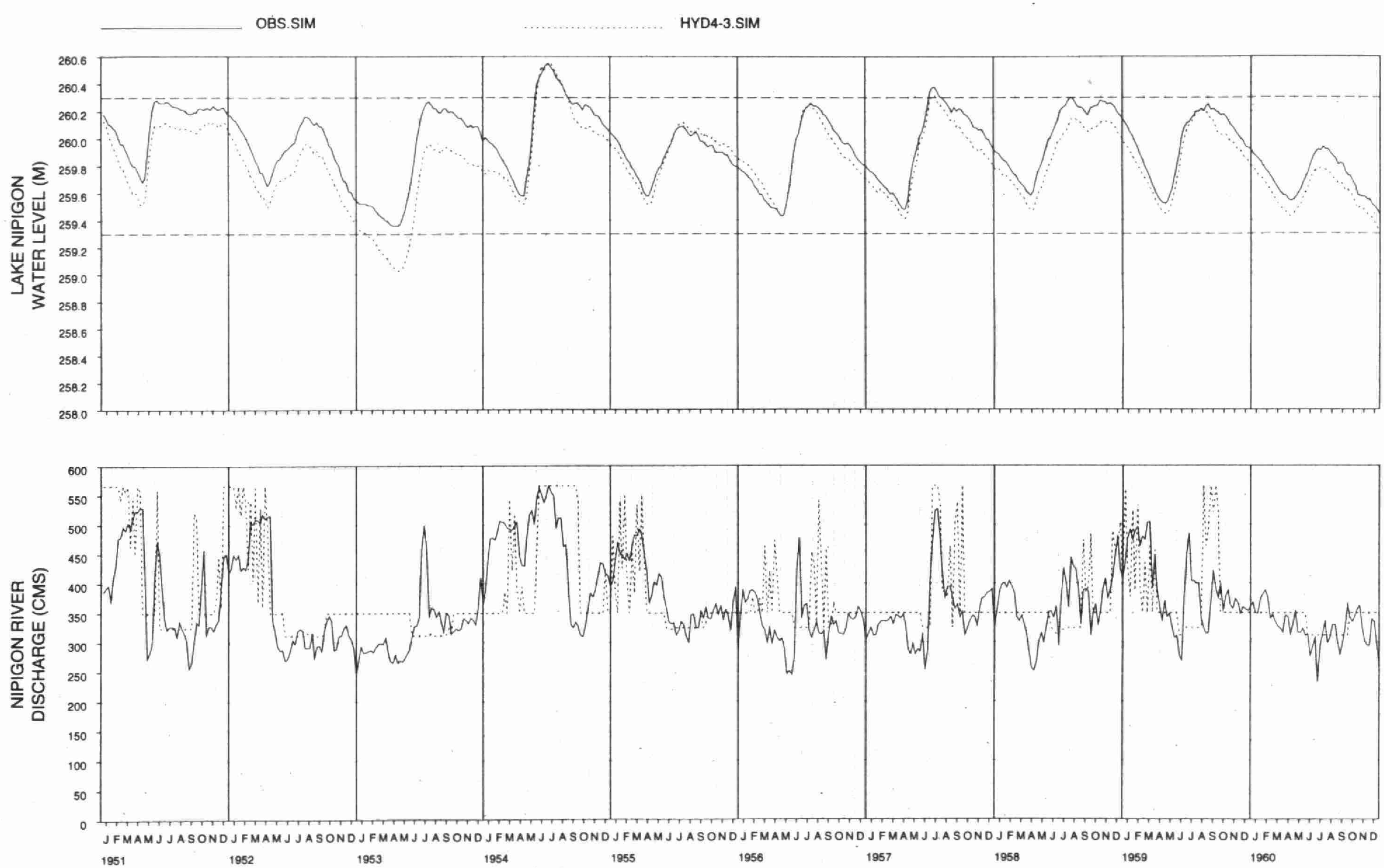
ANNUAL POWER

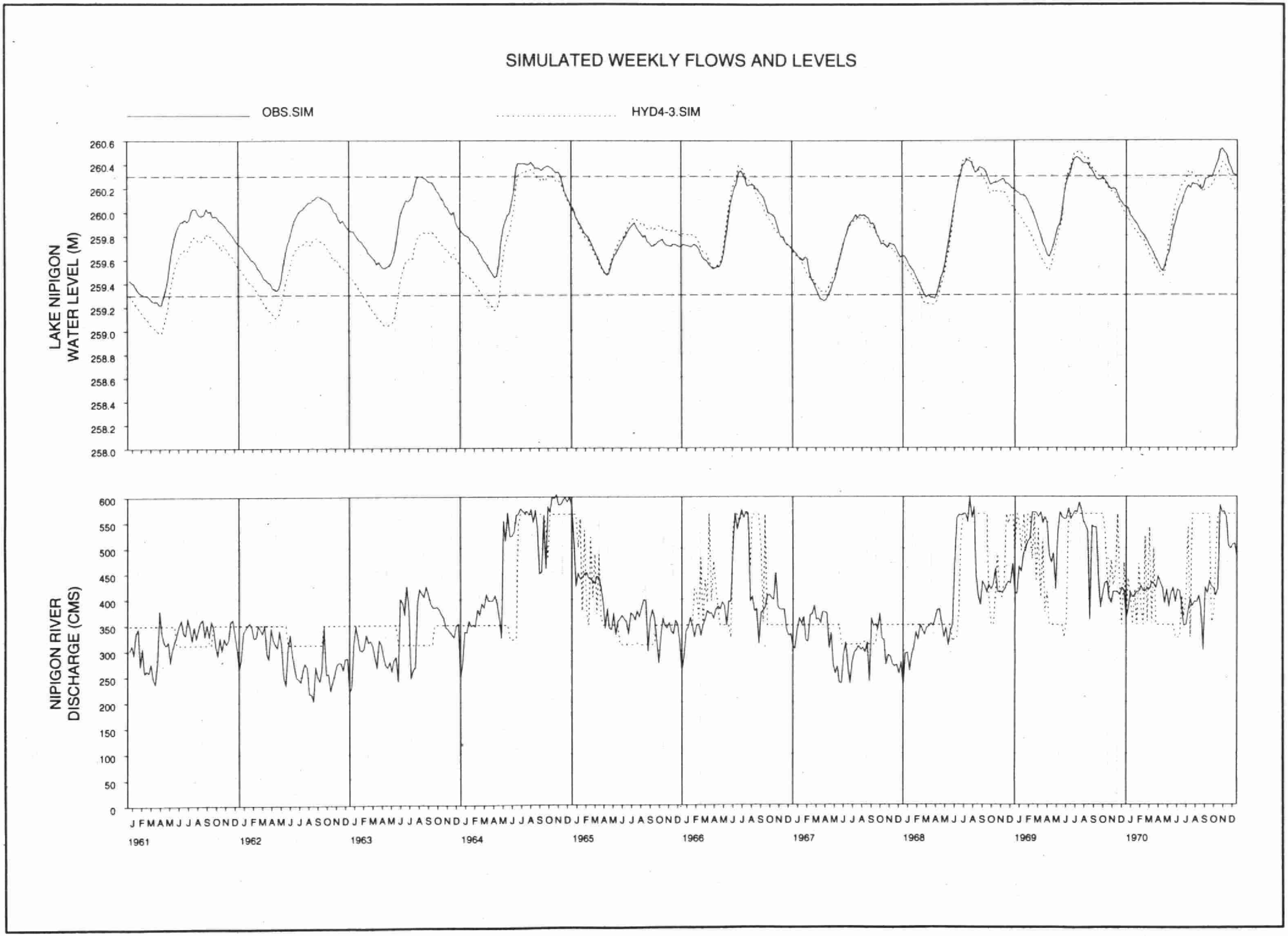
YEAR	ON PEAK MWH	OFF PEAK MWH	TOTAL MWH	ON PEAK $	OFF PEAK $	TOTAL $
1951	1809602.	123893.	1933494.	33122730.	1333875.	34456600.
1952	911515.	473003.	1384519.	16974860.	6184768.	23159630.
1953	1291510.	457110.	1748620.	22350850.	6532819.	28883670.
1954	1725209.	231358.	1956567.	31063770.	3081089.	34144860.
1955	1195725.	462626.	1658351.	20890040.	6279228.	27169270.
1956	1089739.	487767.	1577505.	19089630.	6598360.	25687990.
1957	1292436.	432214.	1724650.	22656630.	5958018.	28614650.
1958	1334143.	421796.	1755939.	23531070.	5623692.	29154770.
1959	1168300.	500303.	1668603.	20425500.	6681554.	27107060.
1960	686471.	652457.	1338928.	11808000.	8534125.	20342130.
1961	1239512.	443719.	1683231.	21214180.	6323315.	27537500.
1962	1055115.	503779.	1558895.	18250350.	6815429.	25065780.
1963	1090311.	513852.	1604163.	18802090.	7049790.	25851880.
1964	1651714.	233262.	1884976.	28585450.	3748171.	32333620.
1965	1283663.	410537.	1694200.	24327600.	4464739.	28792340.
1966	1474252.	336609.	1810860.	26485970.	4432348.	30918320.
1967	957360.	527582.	1484942.	16429230.	7153808.	23583040.
1968	1695725.	184864.	1880590.	28981860.	3113716.	32095570.
1969	1806301.	211037.	2017338.	32641290.	2808772.	35450060.
1970	1565343.	274243.	1839586.	27424200.	3905099.	31329300.
1971	1730689.	173653.	1904342.	31672800.	1961153.	33633950.
1972	1023830.	487601.	1511431.	19830860.	5670370.	25501230.
1973	1135720.	473354.	1609074.	20185600.	6220615.	26406210.
1974	1505746.	366164.	1871911.	26277680.	5116597.	31394270.
1975	951778.	533412.	1485189.	17105920.	7177386.	24283300.
1976	572451.	533929.	1106380.	9707222.	7287983.	16995200.
1977	1450747.	295138.	1745886.	24964500.	4316684.	29281180.
1978	1040274.	506571.	1546845.	17886480.	6960689.	24847170.
1979	977301.	486636.	1463937.	17035890.	6492357.	23528250.
1980	721081.	548356.	1269436.	13111060.	6988051.	20099110.
1981	447319.	562975.	1010294.	7937941.	7131898.	15069840.
1982	953913.	458125.	1412038.	16413670.	6023228.	22436900.
1983	1002603.	468697.	1471300.	18508120.	5802970.	24311090.
1984	1056116.	479394.	1535510.	17931210.	6729470.	24660680.
1985	1511935.	342190.	1854125.	26691370.	4555952.	31247320.
1986	1004554.	476562.	1481116.	17910760.	6106431.	24017190.

Option HYDRO

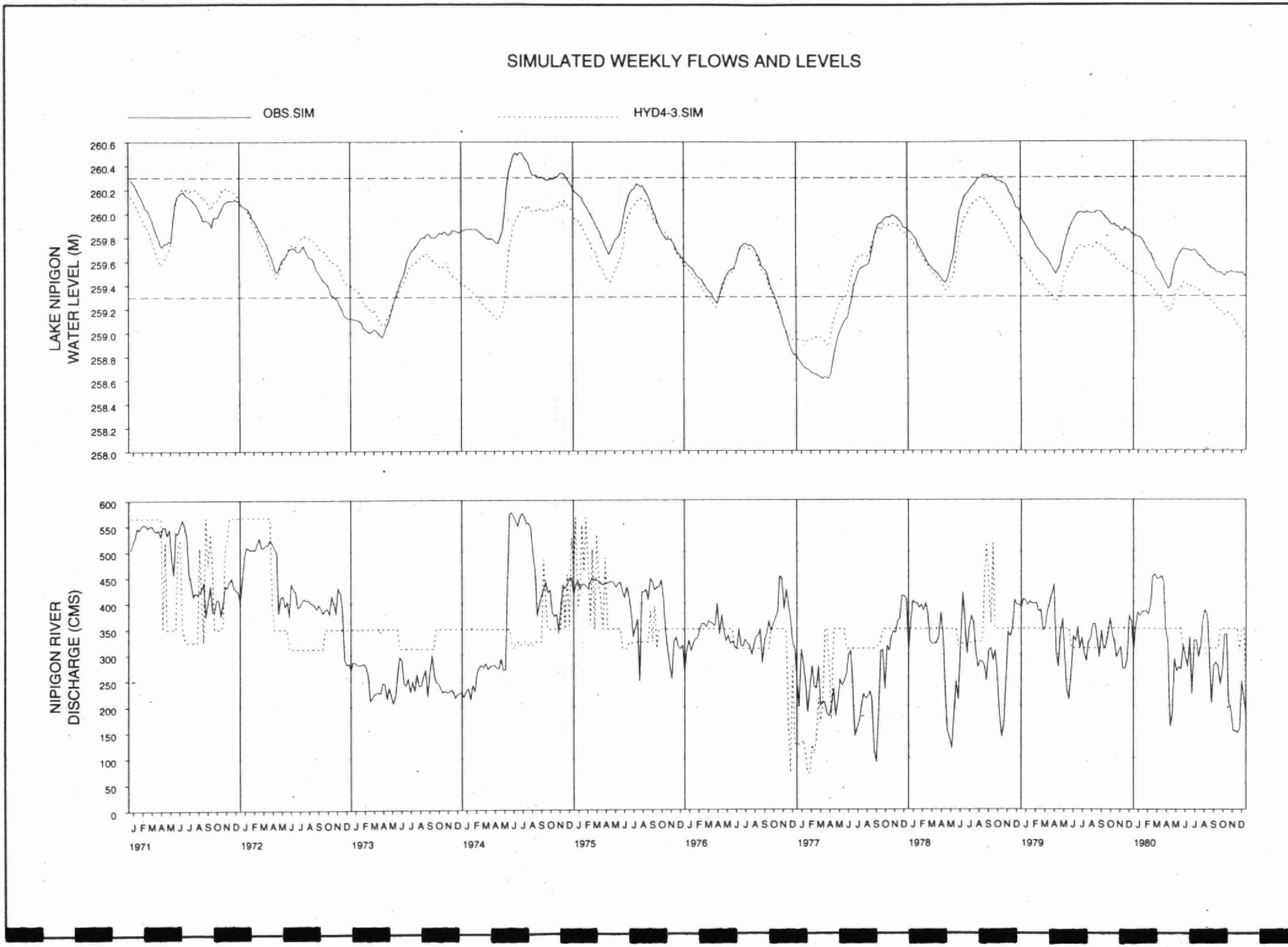
- Time series of simulated average weekly Lake Nipigon water levels and Nipigon River flows (1951-86)
- Performance of average Lake Nipigon level and Nipigon River flow and minimum and maximum flows relative to penalty functions
- Lake Nipigon water level data: fall to spring drawdown; maximum fall; minimum spring; peaking data
- Power produced and dollar value

SIMULATED WEEKLY FLOWS AND LEVELS

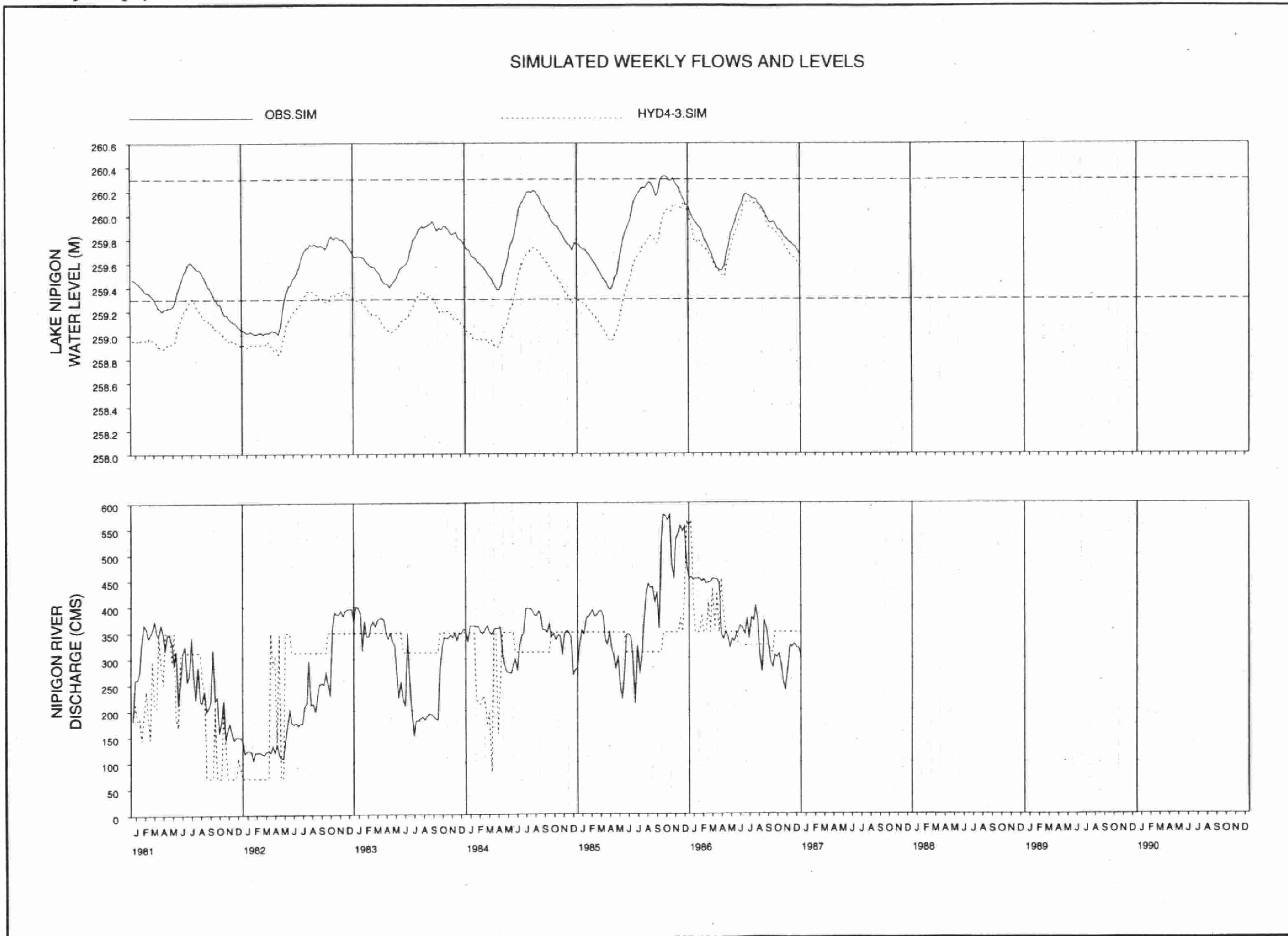


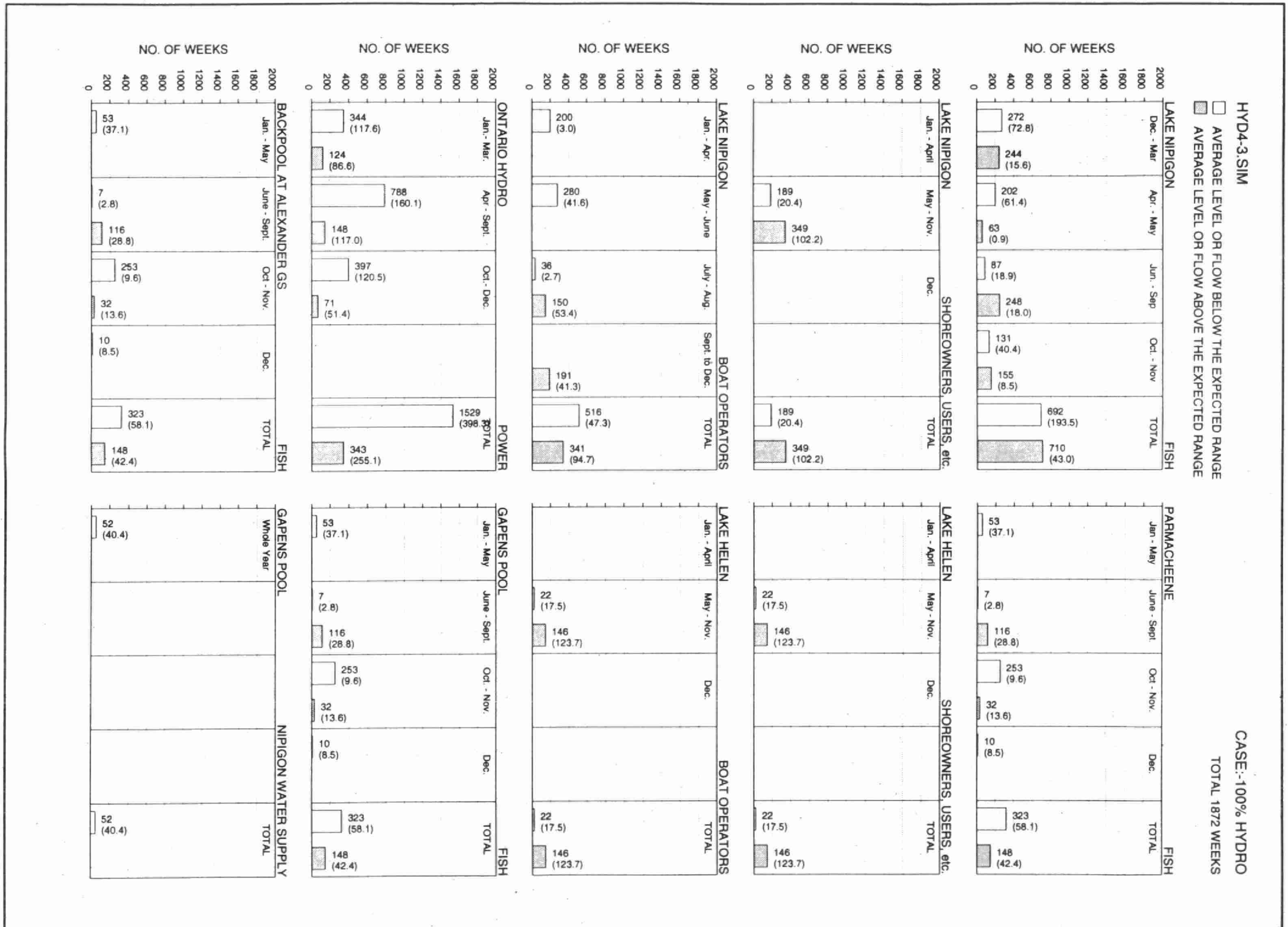


SIMULATED WEEKLY FLOWS AND LEVELS
OBS.SIM
HYD4-3.SIM
LAKE NIPIGON WATER LEVEL (M)
260.6
260.4
260.2
260.0
259.8
259.6
259.4
259.2
259.0
258.8
258.6
258.4
258.2
258.0
NIPIGON RIVER DISCHARGE (CMS)
600
550
500
450
400
350
300
250
200
150
100
50
0
J F M A M J J A S O N D
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970



SIMULATED WEEKLY FLOWS AND LEVELS
OBS.SIM
HYD4-3.SIM
LAKE NIPIGON WATER LEVEL (M)
260.6
260.4
260.2
260.0
259.8
259.6
259.4
259.2
259.0
258.8
258.6
258.4
258.2
258.0
NIPIGON RIVER DISCHARGE (CMS)
600
550
500
450
400
350
300
250
200
150
100
50
0
J F M A M J J A S O N D
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980


SIMULATED WEEKLY FLOWS AND LEVELS
OBS.SIM
HYD4-3.SIM
LAKE NIPIGON WATER LEVEL (M)
260.6
260.4
260.2
260.0
259.8
259.6
259.4
259.2
259.0
258.8
258.6
258.4
258.2
258.0
NIPIGON RIVER DISCHARGE (CMS)
600
550
500
450
400
350
300
250
200
150
100
50
0
J F M A M J J A S O N D
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990


HYD4-3.SIM
AVERAGE LEVEL OR FLOW BELOW THE EXPECTED RANGE
AVERAGE LEVEL OR FLOW ABOVE THE EXPECTED RANGE
CASE:-100% HYDRO
TOTAL 1872 WEEKS
NO. OF WEEKS
0 200 400 600 800 1000 1200 1400 1600 1800 2000
LAKE NIPIGON FISH
Dec. - Mar 272 (72.8) 244 (15.6)
Apr. - May 202 (61.4) 63 (0.9)
Jun. - Sep 87 (18.9) 248 (18.0)
Oct. - Nov 131 (40.4) 155 (8.5)
TOTAL 692 (193.5) 710 (43.0)
LAKE NIPIGON SHOREOWNERS, USERS, etc.
Jan. - April
May - Nov. 189 (20.4) 349 (102.2)
Dec.
TOTAL 189 (20.4) 349 (102.2)
LAKE NIPIGON BOAT OPERATORS
Jan. - Apr. 200 (3.0)
May - June 280 (41.6)
July - Aug. 36 (2.7) 150 (53.4)
Sept. to Dec. 191 (41.3)
TOTAL 516 (47.3) 341 (94.7)
ONTARIO HYDRO POWER
Jan. - Mar. 344 (117.6) 124 (86.6)
Apr. - Sept. 788 (160.1) 148 (117.0)
Oct. - Dec. 397 (120.5) 71 (51.4)
TOTAL 1529 (398.3) 343 (255.1)
BACKPOOL AT ALEXANDER GS FISH
Jan. - May 53 (37.1)
June - Sept. 7 (2.8) 116 (28.8)
Oct - Nov. 253 (9.6) 32 (13.6)
Dec. 10 (8.5)
TOTAL 323 (58.1) 148 (42.4)
PARMACHEENE FISH
Jan - May 53 (37.1)
June - Sept. 7 (2.8) 116 (28.8)
Oct. - Nov. 253 (9.6) 32 (13.6)
Dec. 10 (8.5)
TOTAL 323 (58.1) 148 (42.4)
LAKE HELEN SHOREOWNERS, USERS, etc.
Jan. - April
May - Nov. 22 (17.5) 146 (123.7)
Dec.
TOTAL 22 (17.5) 146 (123.7)
LAKE HELEN BOAT OPERATORS
Jan. - April
May - Nov. 22 (17.5) 146 (123.7)
Dec.
TOTAL 22 (17.5) 146 (123.7)
GAPENS POOL FISH
Jan. - May 53 (37.1)
June - Sept. 7 (2.8) 116 (28.8)
Oct. - Nov. 253 (9.6) 32 (13.6)
Dec. 10 (8.5)
TOTAL 323 (58.1) 148 (42.4)
GAPENS POOL NIPIGON WATER SUPPLY
Whole Year 52 (40.4)
TOTAL 52 (40.4)

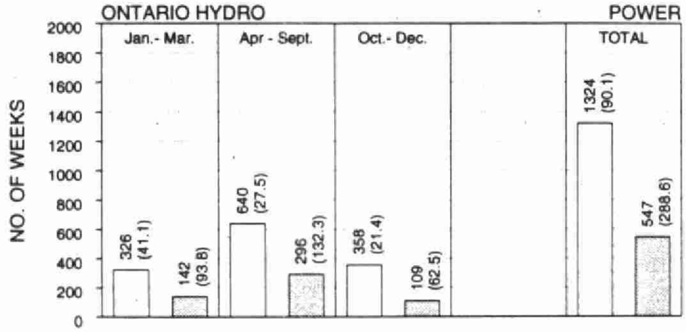
HYD4-3.SIM

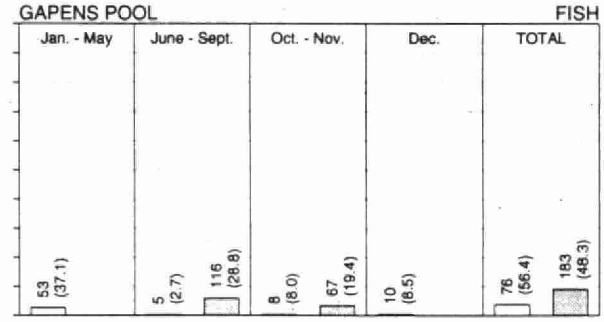
CASE:-100% HYDRO

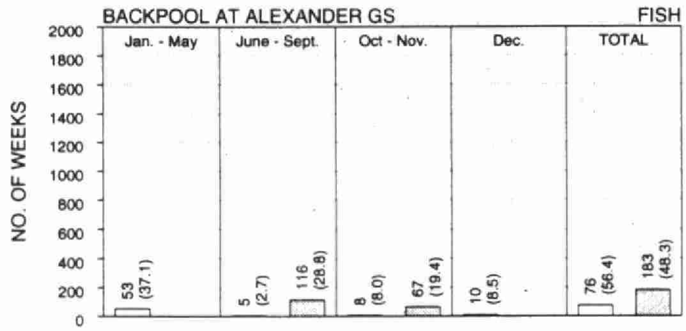
TOTAL 1872 WEEKS

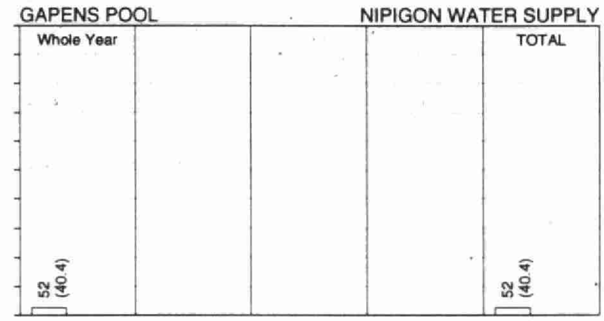
MAXIMUM FLOW BELOW THE EXPECTED RANGE

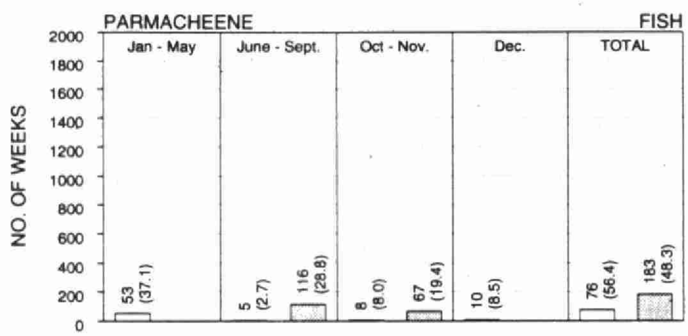
MAXIMUM FLOW ABOVE THE EXPECTED RANGE

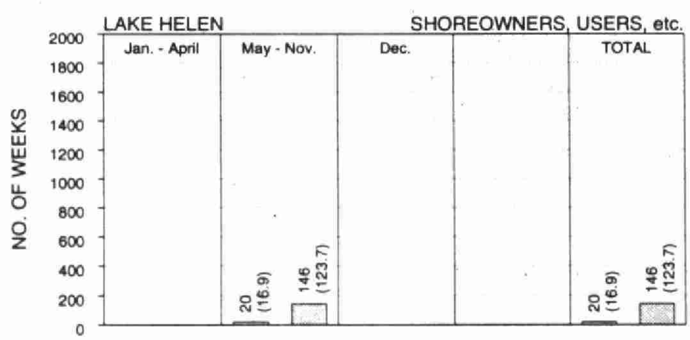


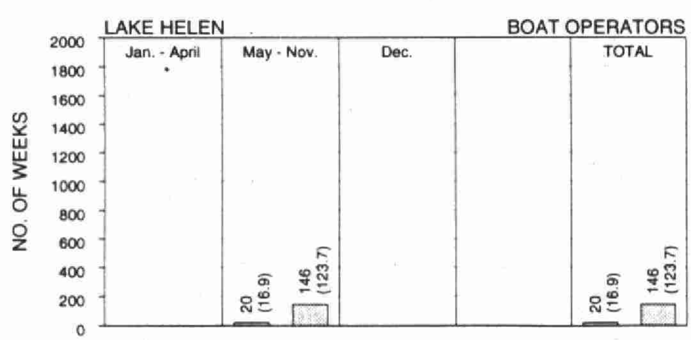












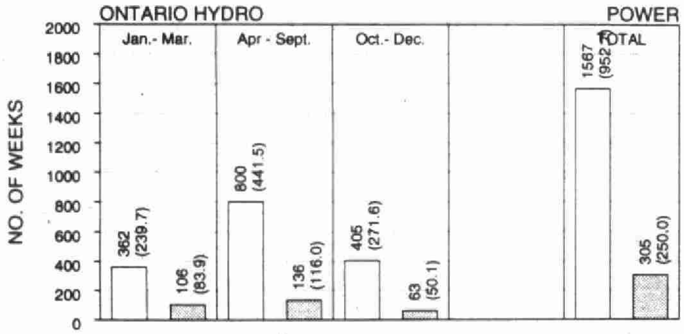
HYD4-3.SIM

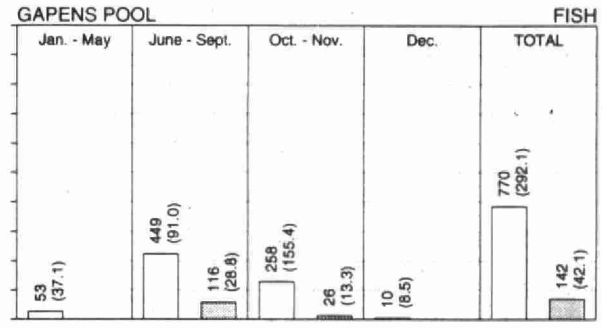
CASE:-100% HYDRO

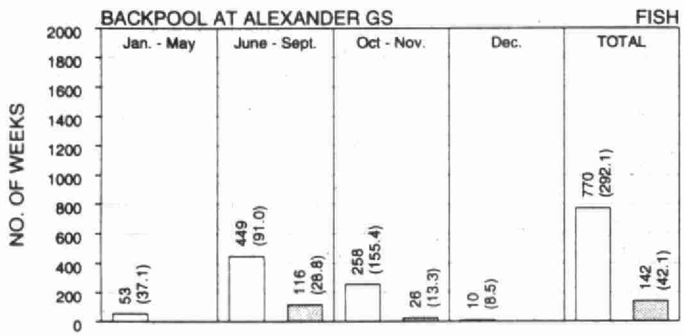
TOTAL 1872 WEEKS

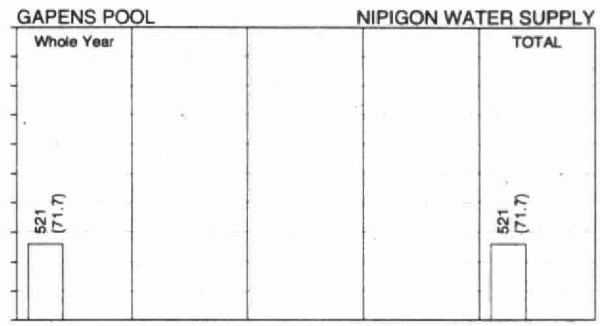
☐ MINIMUM FLOW BELOW THE EXPECTED RANGE

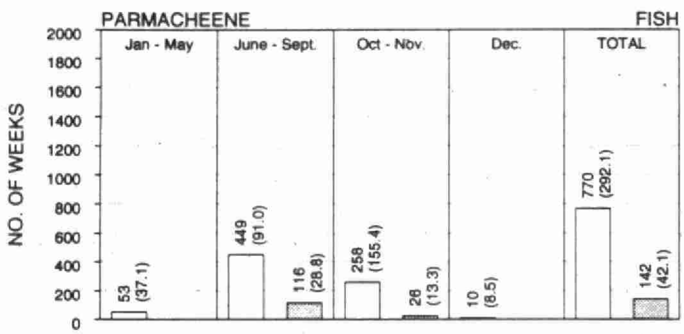
▨ MINIMUM FLOW ABOVE THE EXPECTED RANGE

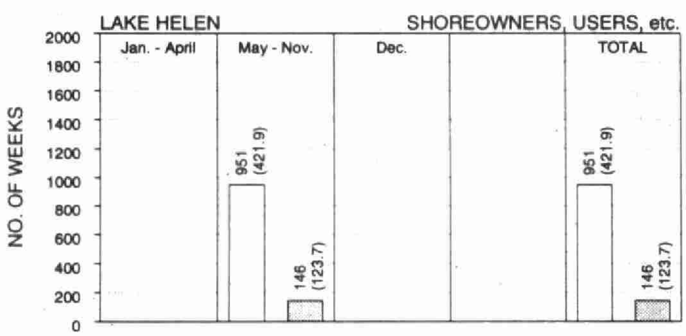


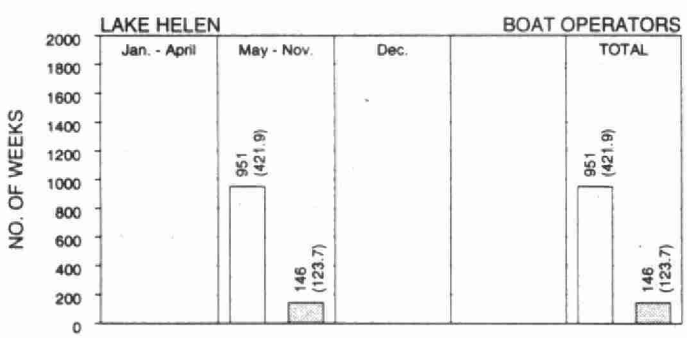












HYD4-3.SIM
CASE:-100% HYDRO

INCREMENTAL CHANGE

FROM:	0	42	260.12	TO:	1	15	259.49	0.63
FROM:	1	39	259.79	TO:	2	16	259.03	0.76
FROM:	2	39	259.91	TO:	3	15	259.52	0.39
FROM:	3	39	260.10	TO:	4	15	259.51	0.59
FROM:	4	39	260.01	TO:	5	17	259.43	0.58
FROM:	5	39	259.96	TO:	6	15	259.41	0.55
FROM:	6	39	260.03	TO:	7	14	259.47	0.56
FROM:	7	43	260.13	TO:	8	17	259.44	0.69
FROM:	8	39	260.03	TO:	9	14	259.43	0.60
FROM:	9	39	259.60	TO:	10	14	258.98	0.62
FROM:	10	39	259.77	TO:	11	16	259.11	0.66
FROM:	11	39	259.74	TO:	12	16	259.04	0.70
FROM:	12	39	259.82	TO:	13	15	259.17	0.65
FROM:	13	40	260.31	TO:	14	16	259.47	0.84
FROM:	14	41	259.89	TO:	15	14	259.53	0.36
FROM:	15	39	259.98	TO:	16	14	259.32	0.66
FROM:	16	39	259.81	TO:	17	10	259.22	0.59
FROM:	17	39	260.19	TO:	18	15	259.50	0.69
FROM:	18	39	260.29	TO:	19	16	259.46	0.83
FROM:	19	44	260.42	TO:	20	14	259.57	0.85
FROM:	20	45	260.22	TO:	21	16	259.46	0.76
FROM:	21	39	259.68	TO:	22	14	259.06	0.62
FROM:	22	39	259.59	TO:	23	16	259.11	0.48
FROM:	23	45	260.10	TO:	24	17	259.43	0.67
FROM:	24	39	259.91	TO:	25	14	259.21	0.70
FROM:	25	39	259.37	TO:	26	14	258.88	0.49
FROM:	26	44	259.92	TO:	27	17	259.35	0.57
FROM:	27	39	260.00	TO:	28	15	259.25	0.75
FROM:	28	39	259.69	TO:	29	16	259.16	0.53
FROM:	29	39	259.18	TO:	30	14	258.89	0.29
FROM:	30	39	259.05	TO:	31	16	258.84	0.21
FROM:	31	45	259.36	TO:	32	17	259.02	0.34
FROM:	32	40	259.21	TO:	33	14	258.89	0.32
FROM:	33	39	259.55	TO:	34	15	258.94	0.61
FROM:	34	44	260.09	TO:	35	16	259.48	0.61

ANNUAL DRAWDOWN (M):
AVERAGE = 0.59
ST.DEV. = 0.16
MAXIMUM = 0.85
MINIMUM = 0.21

MAXIMUM ELEVATION IN FALL (M):
AVERAGE = 259.85
ST.DEV. = 0.33
MAXIMUM = 260.42
MINIMUM = 259.05

MINIMUM ELEVATION IN SPRING (M):
AVERAGE = 259.26
ST.DEV. = 0.23
MAXIMUM = 259.57
MINIMUM = 258.84

MINIMUM OFF PEAK FLOWS
FOR WEEK 23-39 Q= 170.00
THE REST Q= 270.00

		NO. OF WEEKS
NO PEAKING	=	361
PEAKING	=	1509
QON-QOFF > 100 CMS	=	1435
QON-QOFF > 200 CMS	=	472
QON-QOFF > 300 CMS	=	0

**** FOR POWER CALCULATION ****

MINIMUM OFF PEAK FLOWS

FOR WEEK 23-39	Q=	170.00
THE REST	Q=	270.00

		MWh	DOLLARS
ON PEAK	=	51789540.	940360200.
OFF PEAK	=	13607070.	170426000.

ANNUAL AVERAGE

		MWh	DOLLARS
ON PEAK	=	1438598.	26121120.
OFF PEAK	=	377974.	4734057.
		1977	1981-82
ON PEAK	=	3692773.	7971185.
OFF PEAK	=	4005690.	5031029.

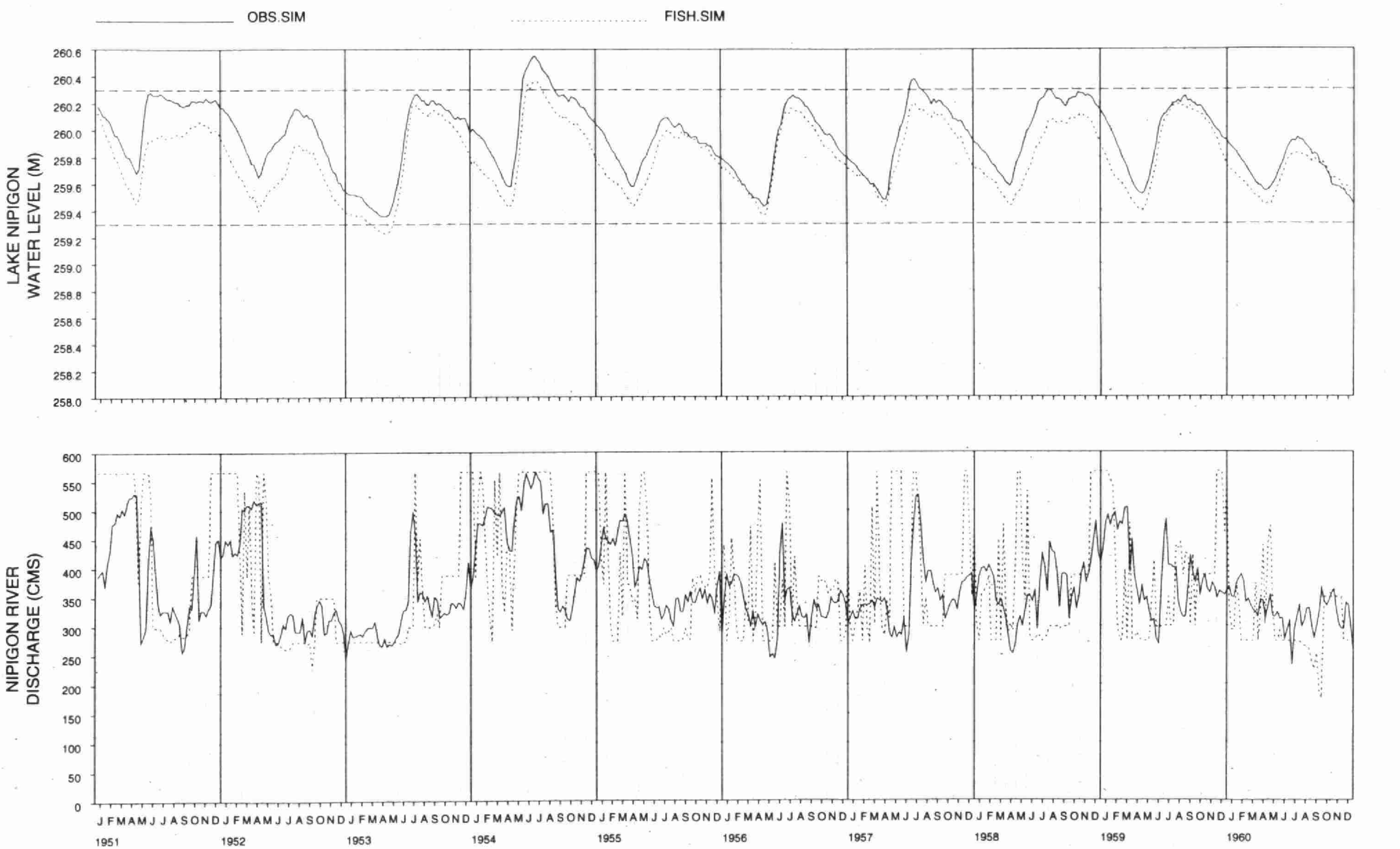
ANNUAL POWER

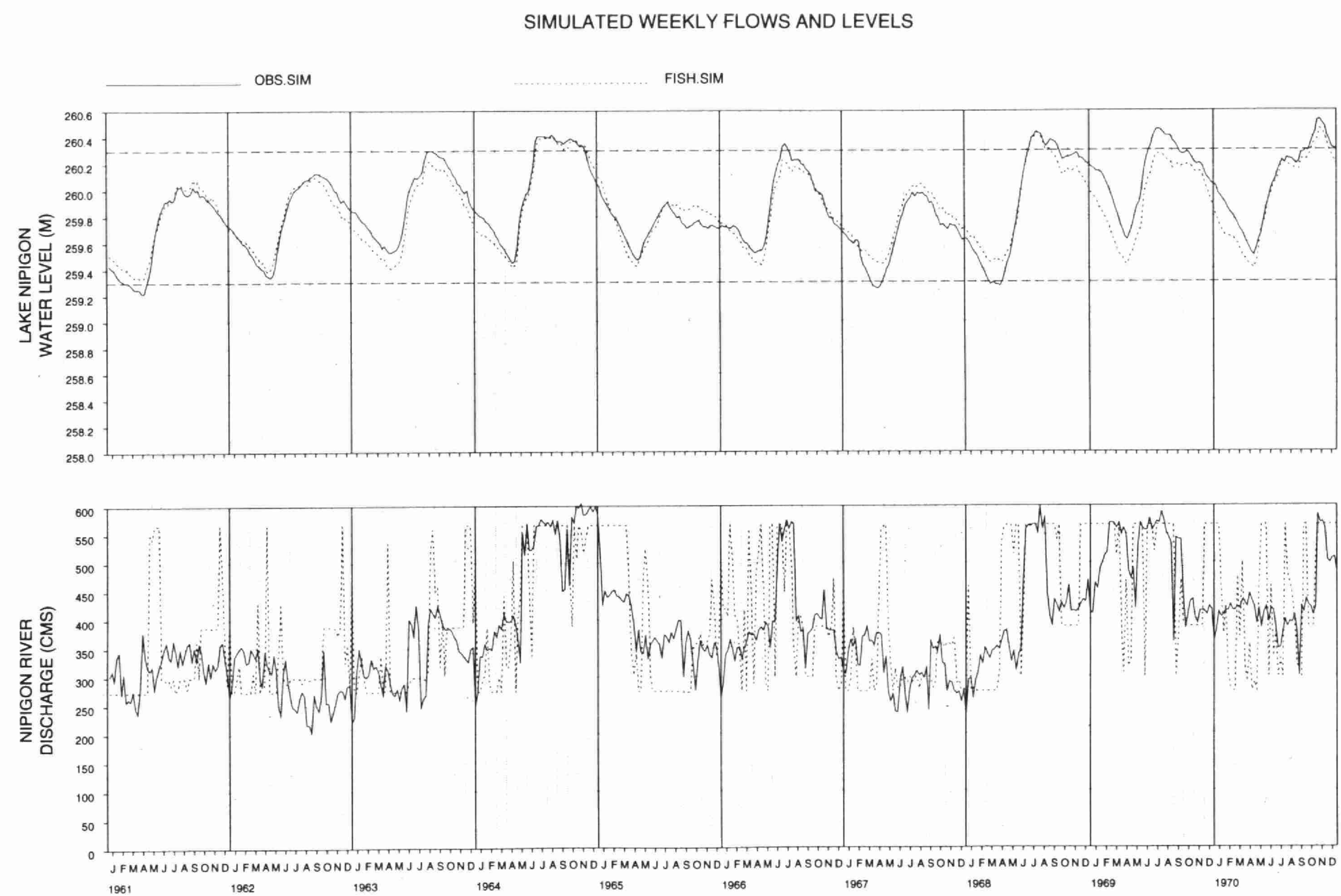
YEAR	ON PEAK MWH	OFF PEAK MWH	TOTAL MWH	ON PEAK $	OFF PEAK $	TOTAL $
1951	1692548.	218360.	1910908.	31325150.	2303815.	33628970.
1952	1552875.	320261.	1873136.	28692790.	3754482.	32447270.
1953	1381694.	425680.	1807374.	25118720.	5372201.	30490920.
1954	1681192.	304600.	1985792.	30238400.	4187142.	34425540.
1955	1474231.	370521.	1844752.	27044200.	4555129.	31599330.
1956	1447003.	412410.	1859413.	26324460.	5201327.	31525790.
1957	1498981.	388701.	1887682.	27102050.	5044655.	32146710.
1958	1467502.	386700.	1854202.	26643330.	4789435.	31432760.
1959	1547515.	346992.	1894507.	28413720.	4339108.	32752820.
1960	1382570.	425680.	1808251.	25133710.	5372201.	30505910.
1961	1383295.	425680.	1808975.	25146680.	5372201.	30518880.
1962	1382570.	425680.	1808251.	25133710.	5372201.	30505910.
1963	1382570.	425680.	1808251.	25133710.	5372201.	30505910.
1964	1757558.	231813.	1989371.	31766810.	2967105.	34733910.
1965	1495674.	353204.	1848878.	27548230.	4195466.	31743700.
1966	1649986.	327033.	1977019.	29749360.	4396878.	34146230.
1967	1384537.	425680.	1810217.	25171720.	5372201.	30543920.
1968	1660111.	314335.	1974446.	30097510.	3960486.	34058000.
1969	1878261.	184606.	2062866.	34433520.	2150148.	36583670.
1970	1759555.	236988.	1996542.	32197250.	2762240.	34959480.
1971	1820033.	163028.	1983061.	33592900.	1619121.	35212020.
1972	1582228.	296493.	1878721.	29429190.	3270376.	32699570.
1973	1382570.	425680.	1808251.	25133710.	5372201.	30505910.
1974	1436264.	401348.	1837612.	26110840.	4988430.	31099270.
1975	1488209.	369159.	1857368.	27454270.	4391291.	31845560.
1976	1267388.	440272.	1707661.	23048830.	5598374.	28647200.
1977	1006756.	504745.	1511502.	17045020.	6542736.	23587760.
1978	1423381.	416550.	1839931.	25877860.	5266304.	31144170.
1979	1382570.	425680.	1808251.	25133710.	5372201.	30505910.
1980	1351213.	442032.	1793245.	24566150.	5625643.	30191800.
1981	512162.	581396.	1093558.	8434366.	7693197.	16127560.
1982	968722.	401775.	1370496.	16479570.	4964945.	21444520.
1983	1382570.	425680.	1808251.	25133710.	5372201.	30505910.
1984	1114536.	532169.	1646706.	19381700.	7057340.	26439040.
1985	1411332.	410575.	1821907.	25654290.	5138062.	30792350.
1986	1399069.	419858.	1818927.	25472720.	5312558.	30785280.

Option FISH

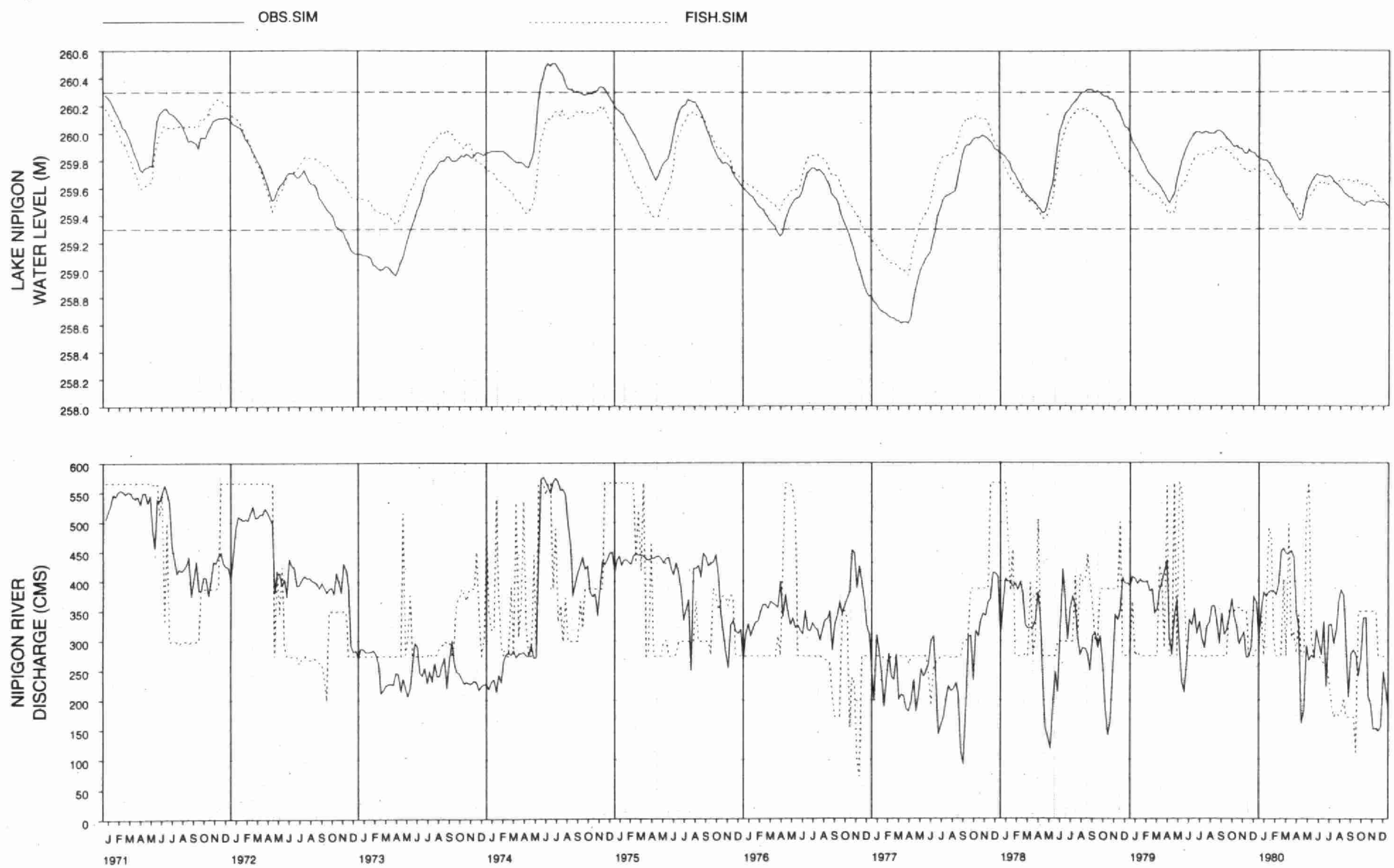
- Time series of simulated average weekly Lake Nipigon water levels and Nipigon River flows (1951-86)
- Performance of average Lake Nipigon level and Nipigon River flow and minimum and maximum flows relative to penalty functions
- Lake Nipigon water level data: fall to spring drawdown; maximum fall; minimum spring; peaking data
- Power produced and dollar value

SIMULATED WEEKLY FLOWS AND LEVELS

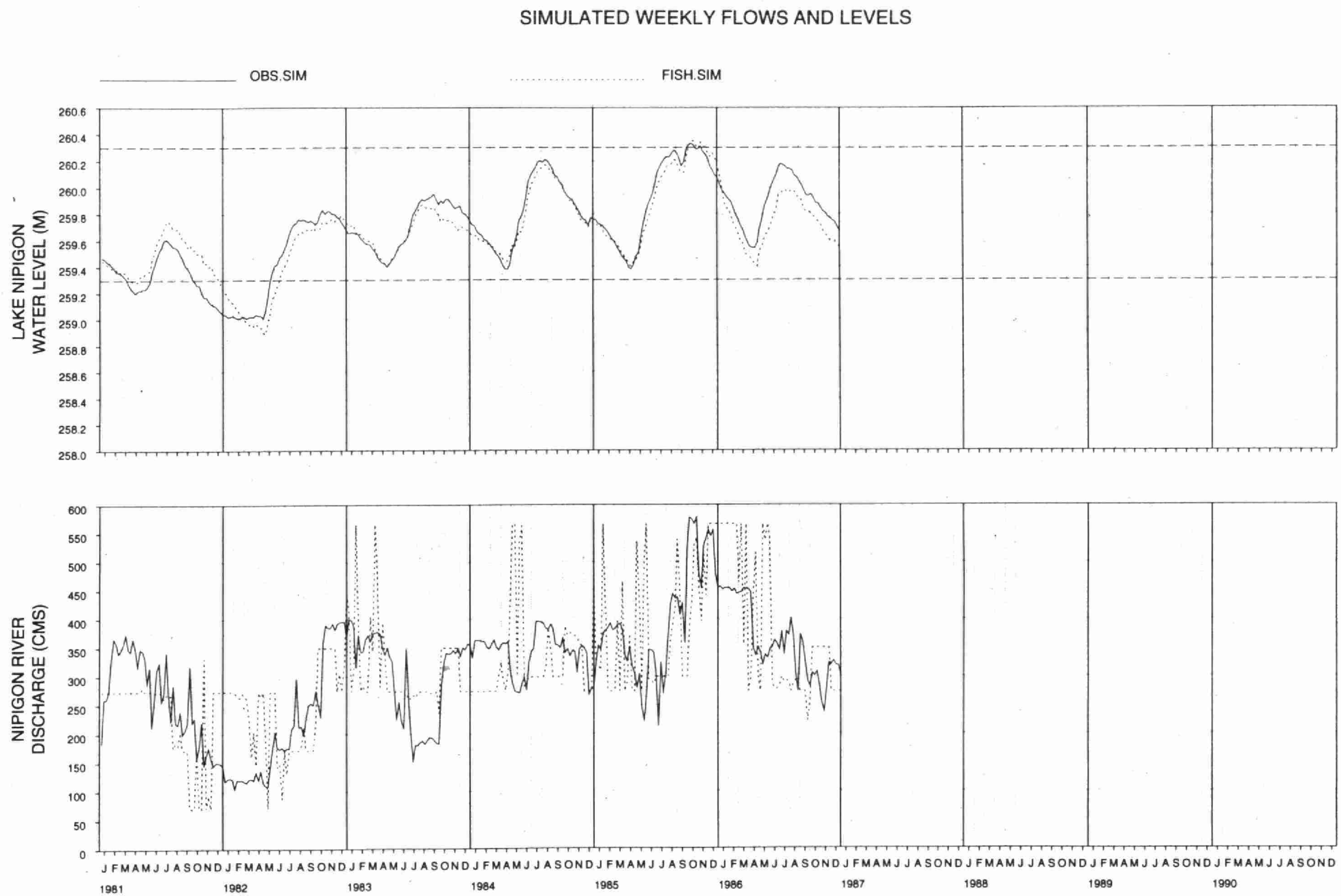



SIMULATED WEEKLY FLOWS AND LEVELS
OBS.SIM
FISH.SIM
LAKE NIPIGON WATER LEVEL (M)
260.6
260.4
260.2
260.0
259.8
259.6
259.4
259.2
259.0
258.8
258.6
258.4
258.2
258.0
NIPIGON RIVER DISCHARGE (CMS)
600
550
500
450
400
350
300
250
200
150
100
50
0
J F M A M J J A S O N D
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970

SIMULATED WEEKLY FLOWS AND LEVELS



16 MAR 1994 13 : 2



16 MAR 1994 13:3

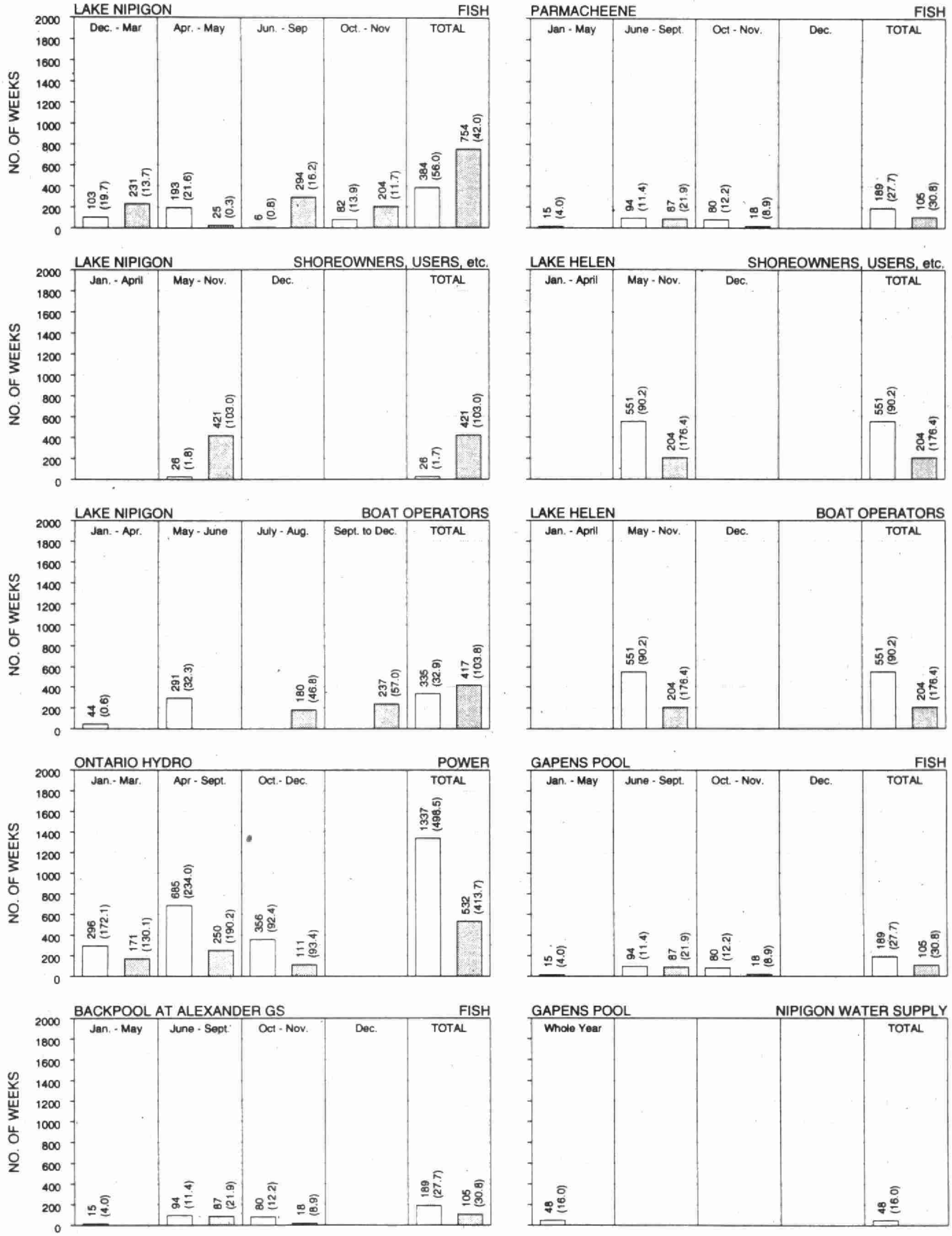
FISH.SIM

CASE: 50% LAKE NIPIGON FISH, 50% NIPIGON RIVER FISH

TOTAL 1872 WEEKS

☐ AVERAGE LEVEL OR FLOW BELOW THE EXPECTED RANGE

▨ AVERAGE LEVEL OR FLOW ABOVE THE EXPECTED RANGE



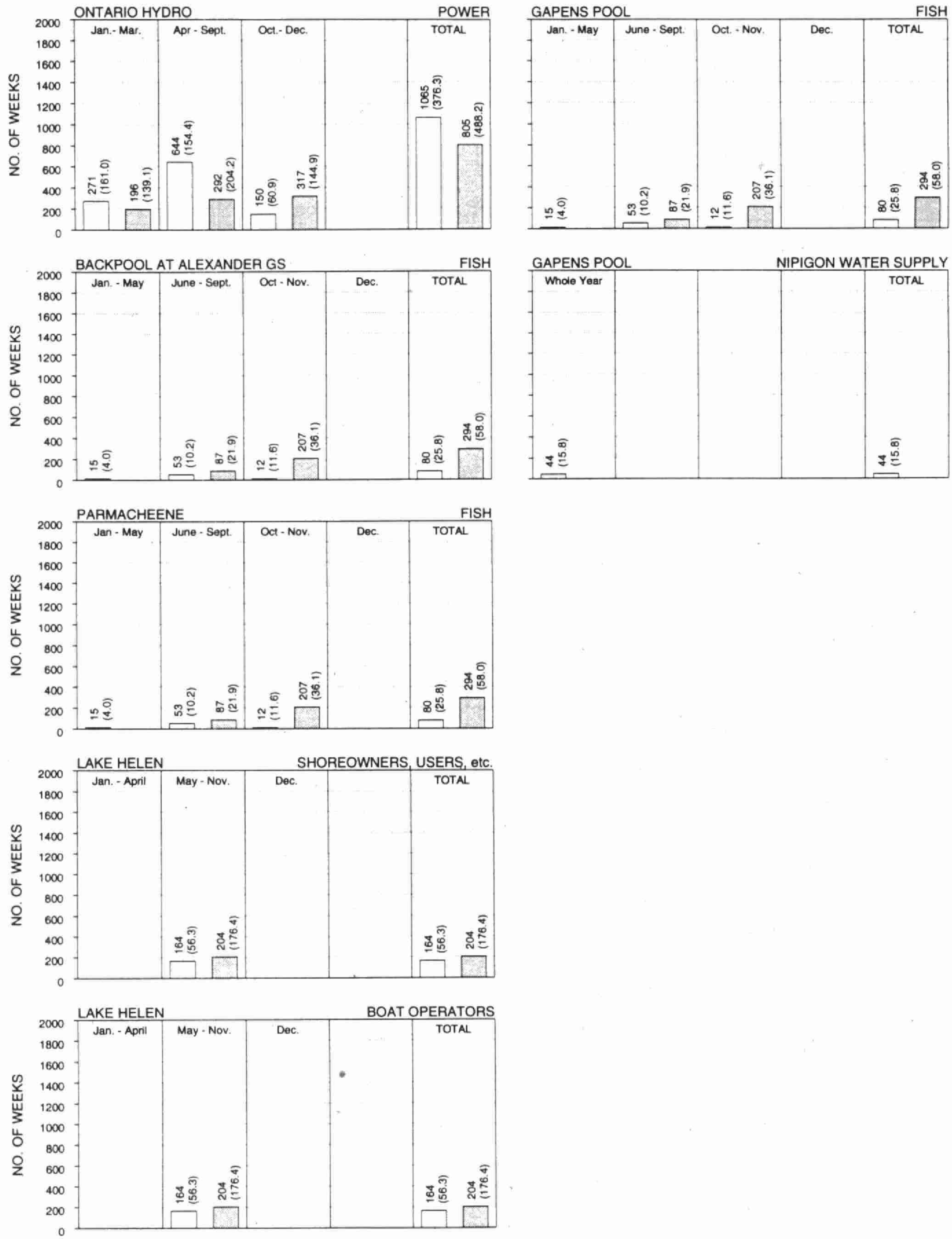
FISH.SIM

CASE: 50% LAKE NIPIGON FISH, 50% NIPIGON RIVER FISH

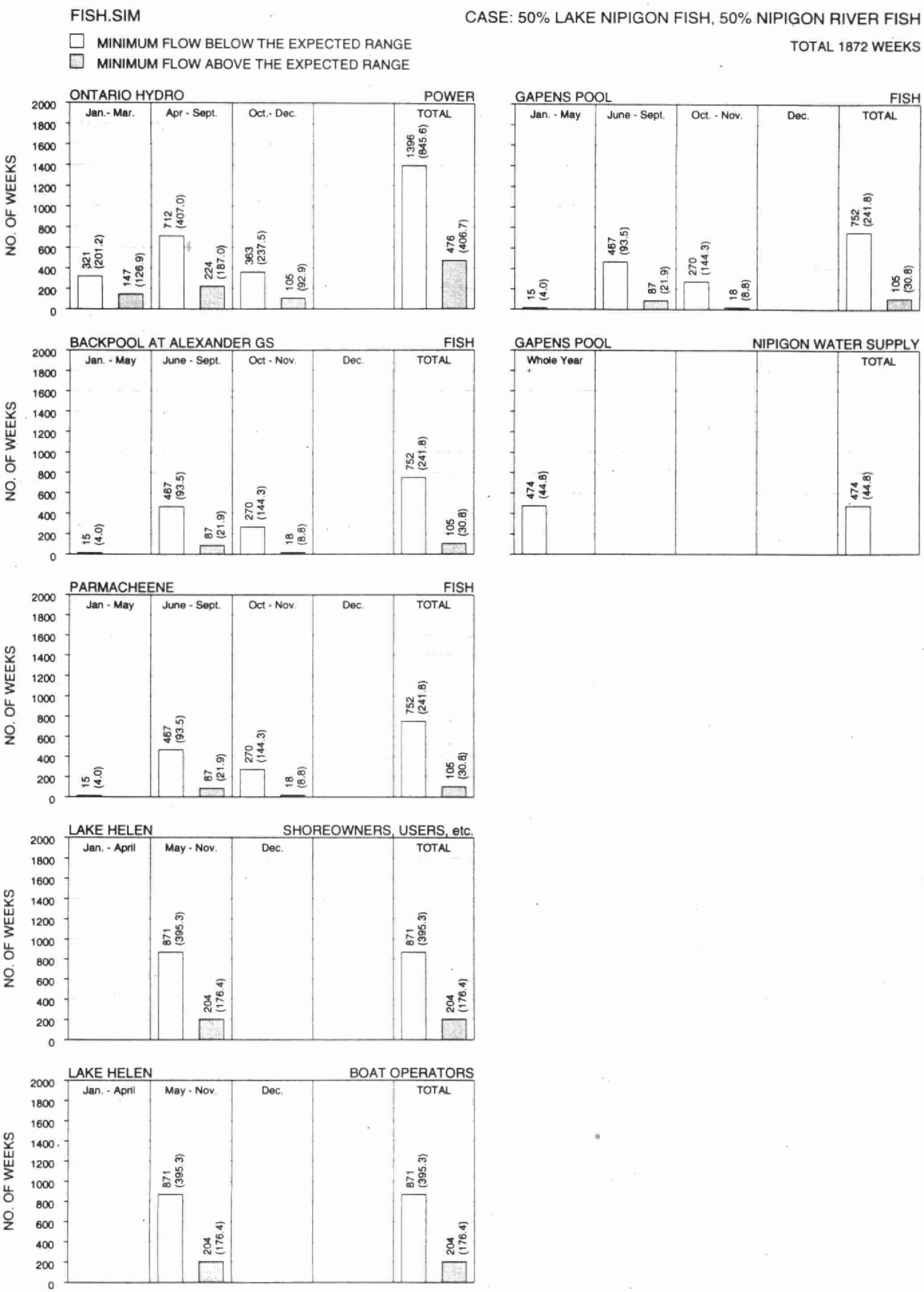
TOTAL 1872 WEEKS

☐ MAXIMUM FLOW BELOW THE EXPECTED RANGE

▩ MAXIMUM FLOW ABOVE THE EXPECTED RANGE



16 MAR 1994 13:3


FISH.SIM
CASE: 50% LAKE NIPIGON FISH, 50% NIPIGON RIVER FISH
MINIMUM FLOW BELOW THE EXPECTED RANGE
MINIMUM FLOW ABOVE THE EXPECTED RANGE
TOTAL 1872 WEEKS
NO. OF WEEKS
ONTARIO HYDRO
POWER
Jan.- Mar.
Apr - Sept.
Oct.- Dec.
TOTAL
321 (201.2)
147 (126.9)
712 (407.0)
224 (187.0)
363 (237.5)
105 (92.9)
1396 (845.6)
476 (406.7)
GAPENS POOL
FISH
Jan. - May
June - Sept.
Oct. - Nov.
Dec.
TOTAL
15 (4.0)
467 (93.5)
87 (21.9)
270 (144.3)
18 (8.8)
752 (241.8)
105 (30.8)
BACKPOOL AT ALEXANDER GS
FISH
Jan. - May
June - Sept.
Oct - Nov.
Dec.
TOTAL
15 (4.0)
467 (93.5)
87 (21.9)
270 (144.3)
18 (8.8)
752 (241.8)
105 (30.8)
GAPENS POOL
NIPIGON WATER SUPPLY
Whole Year
TOTAL
474 (44.8)
474 (44.8)
PARMACHEENE
FISH
Jan - May
June - Sept.
Oct - Nov.
Dec.
TOTAL
15 (4.0)
467 (93.5)
87 (21.9)
270 (144.3)
18 (8.8)
752 (241.8)
105 (30.8)
LAKE HELEN
SHOREOWNERS, USERS, etc.
Jan. - April
May - Nov.
Dec.
TOTAL
871 (395.3)
204 (176.4)
871 (395.3)
204 (176.4)
LAKE HELEN
BOAT OPERATORS
Jan. - April
May - Nov.
Dec.
TOTAL
871 (395.3)
204 (176.4)
871 (395.3)
204 (176.4)
0
200
400
600
800
1000
1200
1400
1600
1800
2000

FISH.SIM
CASE: 50% LAKE NIPIGON FISH, 50% NIPIGON RIVER FISH

INCREMENTAL CHANGE

FROM:	0	42	260.06	TO:	1	15	259.40	0.66
FROM:	1	39	259.77	TO:	2	15	259.23	0.54
FROM:	2	39	260.13	TO:	3	15	259.42	0.71
FROM:	3	39	260.09	TO:	4	15	259.43	0.66
FROM:	4	39	259.93	TO:	5	17	259.36	0.57
FROM:	5	39	259.97	TO:	6	15	259.43	0.54
FROM:	6	39	260.09	TO:	7	14	259.43	0.66
FROM:	7	43	260.12	TO:	8	15	259.40	0.72
FROM:	8	39	260.13	TO:	9	14	259.44	0.69
FROM:	9	39	259.74	TO:	10	14	259.33	0.41
FROM:	10	39	260.02	TO:	11	16	259.38	0.64
FROM:	11	39	260.06	TO:	12	15	259.41	0.65
FROM:	12	39	260.14	TO:	13	15	259.41	0.73
FROM:	13	42	260.39	TO:	14	16	259.42	0.97
FROM:	14	41	259.89	TO:	15	17	259.43	0.46
FROM:	15	39	260.06	TO:	16	15	259.44	0.62
FROM:	16	39	259.92	TO:	17	10	259.45	0.47
FROM:	17	46	260.17	TO:	18	15	259.43	0.74
FROM:	18	40	260.19	TO:	19	16	259.40	0.79
FROM:	19	44	260.46	TO:	20	14	259.60	0.86
FROM:	20	46	260.25	TO:	21	16	259.43	0.82
FROM:	21	39	259.76	TO:	22	14	259.34	0.42
FROM:	22	39	259.95	TO:	23	15	259.42	0.53
FROM:	23	45	260.20	TO:	24	15	259.39	0.81
FROM:	24	39	259.97	TO:	25	14	259.44	0.53
FROM:	25	39	259.61	TO:	26	14	258.96	0.65
FROM:	26	40	260.13	TO:	27	16	259.38	0.75
FROM:	27	39	260.10	TO:	28	15	259.41	0.69
FROM:	28	39	259.86	TO:	29	15	259.41	0.45
FROM:	29	39	259.64	TO:	30	14	259.28	0.36
FROM:	30	39	259.53	TO:	31	17	258.89	0.64
FROM:	31	45	259.76	TO:	32	15	259.42	0.34
FROM:	32	40	259.76	TO:	33	14	259.44	0.32
FROM:	33	39	259.97	TO:	34	15	259.40	0.57
FROM:	34	40	260.35	TO:	35	16	259.40	0.95

ANNUAL DRAWDOWN (M):
AVERAGE = 0.63
ST.DEV. = 0.16
MAXIMUM = 0.97
MINIMUM = 0.32

MAXIMUM ELEVATION IN FALL (M):
AVERAGE = 260.00
ST.DEV. = 0.22
MAXIMUM = 260.46
MINIMUM = 259.53

MINIMUM ELEVATION IN SPRING (M):
AVERAGE = 259.38
ST.DEV. = 0.13
MAXIMUM = 259.60
MINIMUM = 258.89

MINIMUM OFF PEAK FLOWS
FOR WEEK 23-39 Q= 170.00
THE REST Q= 270.00

		NO. OF WEEKS
NO PEAKING	=	495
PEAKING	=	1375
QON-QOFF > 100 CMS	=	765
QON-QOFF > 200 CMS	=	42
QON-QOFF > 300 CMS	=	0

**** FOR POWER CALCULATION ****

MINIMUM OFF PEAK FLOWS

FOR WEEK 23-39	Q=	170.00
THE REST	Q=	270.00

		MWh	DOLLARS
ON PEAK	=	50219930.	911327100.
OFF PEAK	=	12188140.	152257100.

ANNUAL AVERAGE

		MWh	DOLLARS
ON PEAK	=	1394998.	25314640.
OFF PEAK	=	338559.	4229364.
		1977	1981-82
ON PEAK	=	5603844.	9715319.
OFF PEAK	=	4726929.	7819309.

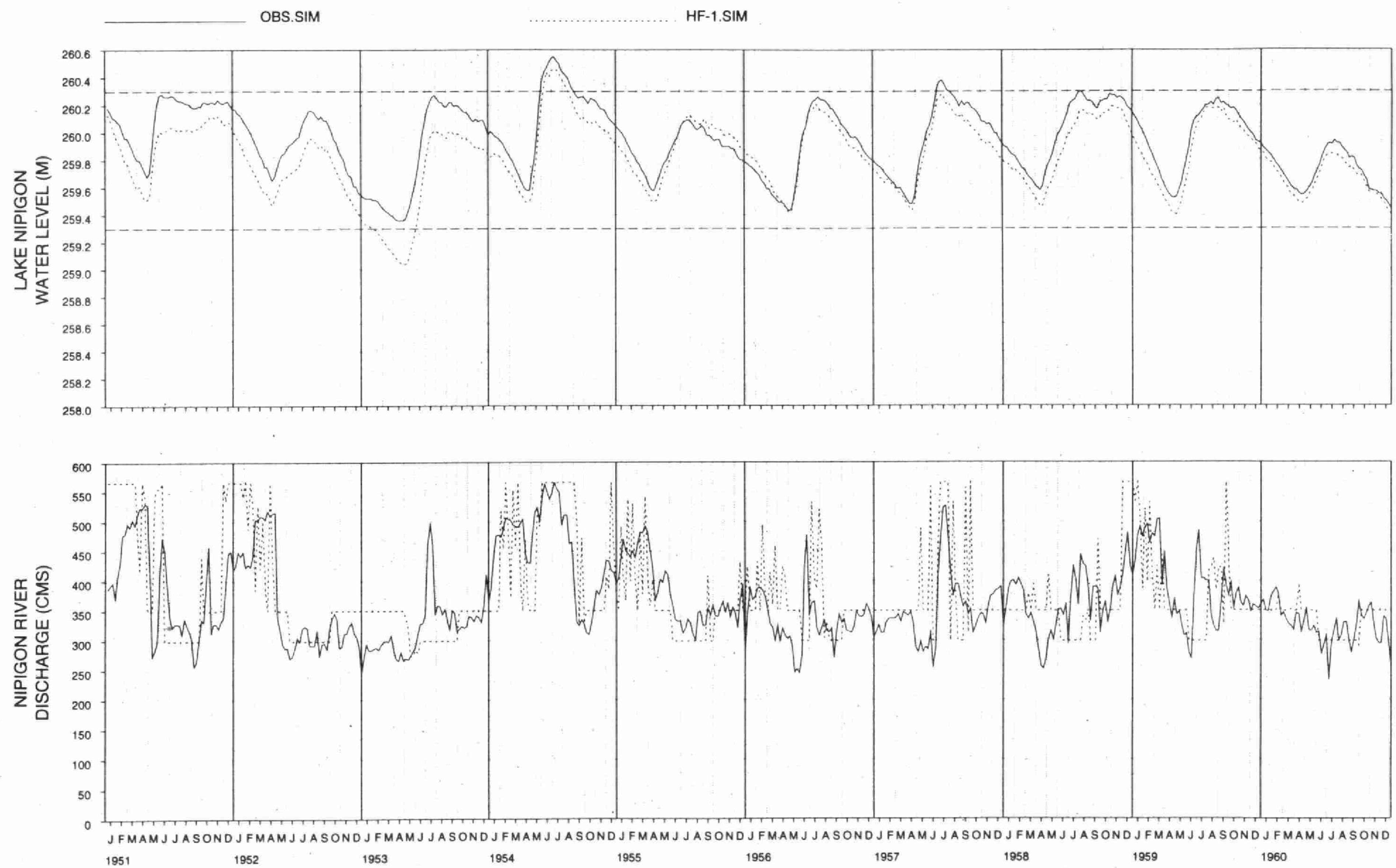
ANNUAL POWER

YEAR	ON PEAK MWH	OFF PEAK MWH	TOTAL MWH	ON PEAK $	OFF PEAK $	TOTAL $
1951	1734176.	180690.	1914866.	31899290.	1964181.	33863480.
1952	1423033.	309050.	1732082.	26401860.	3668857.	30070720.
1953	1274854.	395807.	1670661.	23053410.	4772933.	27826340.
1954	1782023.	208718.	1990741.	32251410.	2628752.	34880170.
1955	1398989.	369027.	1768016.	25345530.	4736769.	30082300.
1956	1335362.	400937.	1736299.	24178010.	5037533.	29215540.
1957	1511826.	324400.	1836226.	27088510.	4151712.	31240220.
1958	1425309.	344718.	1770027.	25804470.	4244361.	30048830.
1959	1465706.	373393.	1839099.	27036050.	4291508.	31327560.
1960	1170346.	411321.	1581667.	21116010.	5247580.	26363590.
1961	1315666.	369521.	1685187.	23426110.	4830308.	28256420.
1962	1265893.	411389.	1677282.	22804290.	5147870.	27952160.
1963	1356043.	368003.	1724046.	24568780.	4559745.	29128530.
1964	1779252.	180391.	1959642.	31663570.	2494044.	34157620.
1965	1537503.	261825.	1799328.	28664830.	2906012.	31570840.
1966	1585890.	323125.	1909015.	28483580.	4333787.	32817360.
1967	1264215.	390632.	1654848.	22685910.	5034907.	27720810.
1968	1707345.	220636.	1927982.	30260700.	3074815.	33335520.
1969	1894442.	149851.	2044292.	34711040.	1660472.	36371520.
1970	1694348.	223914.	1918261.	30769490.	2735630.	33505120.
1971	1798812.	159958.	1958770.	32908680.	1807697.	34716370.
1972	1487285.	275347.	1762632.	27750680.	3032564.	30783240.
1973	1206468.	400705.	1607174.	21709470.	5046414.	26755890.
1974	1539125.	306324.	1845450.	27517410.	3939541.	31456950.
1975	1409483.	335822.	1745304.	26431930.	3860215.	30292140.
1976	1048659.	418058.	1466717.	18663870.	5478103.	24141970.
1977	1080908.	510817.	1591724.	19207680.	6618463.	25826140.
1978	1342371.	400085.	1742455.	24599300.	4839108.	29438400.
1979	1227807.	394772.	1622579.	21976890.	5154166.	27131060.
1980	1131415.	386769.	1518184.	20681400.	4836417.	25517810.
1981	796720.	430130.	1226850.	14508310.	5410690.	19919000.
1982	692350.	597988.	1290338.	12450600.	7797675.	20248270.
1983	1212480.	405466.	1617946.	22171810.	5082607.	27254410.
1984	1297767.	377041.	1674808.	23118280.	4927607.	28045890.
1985	1524844.	304138.	1828982.	27570640.	3776215.	31346860.
1986	1500886.	267344.	1768230.	27851220.	3127545.	30978770.

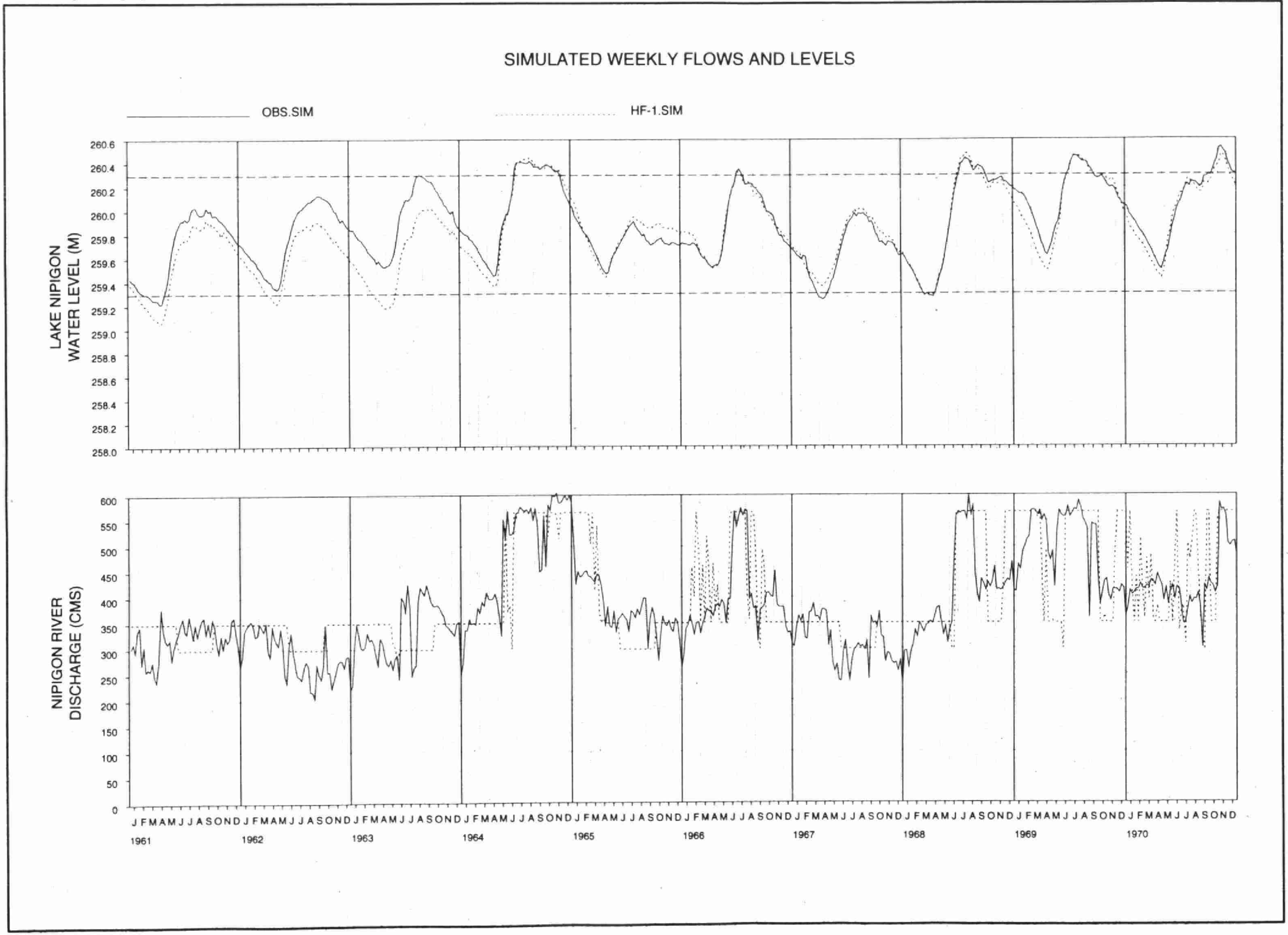
Option HYDFISH

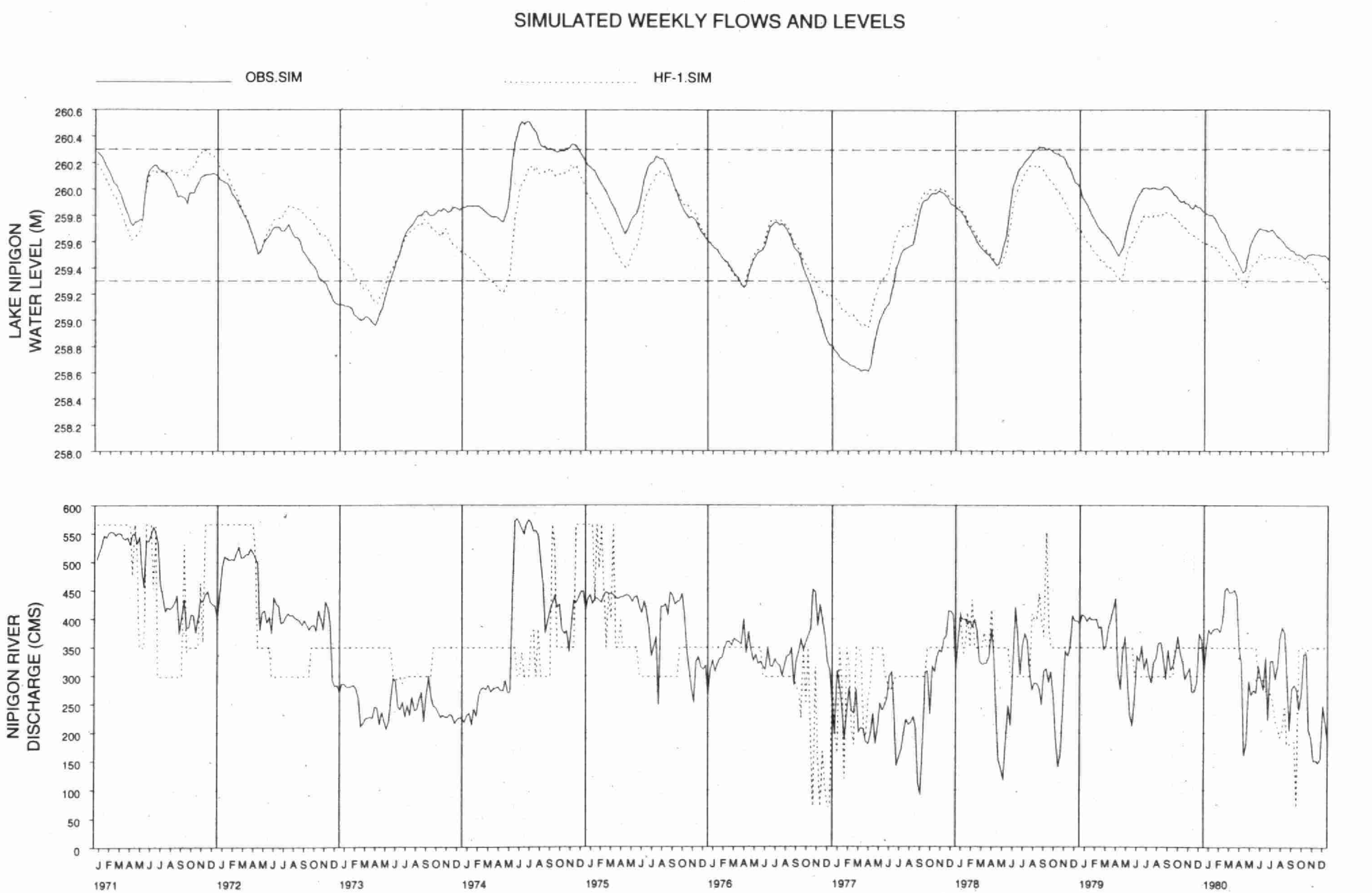
- Time series of simulated average weekly Lake Nipigon water levels and Nipigon River flows (1951-86)
- Performance of average Lake Nipigon level and Nipigon River flow and minimum and maximum flows relative to penalty functions
- Lake Nipigon water level data: fall to spring drawdown; maximum fall; minimum spring; peaking data
- Power produced and dollar value

SIMULATED WEEKLY FLOWS AND LEVELS

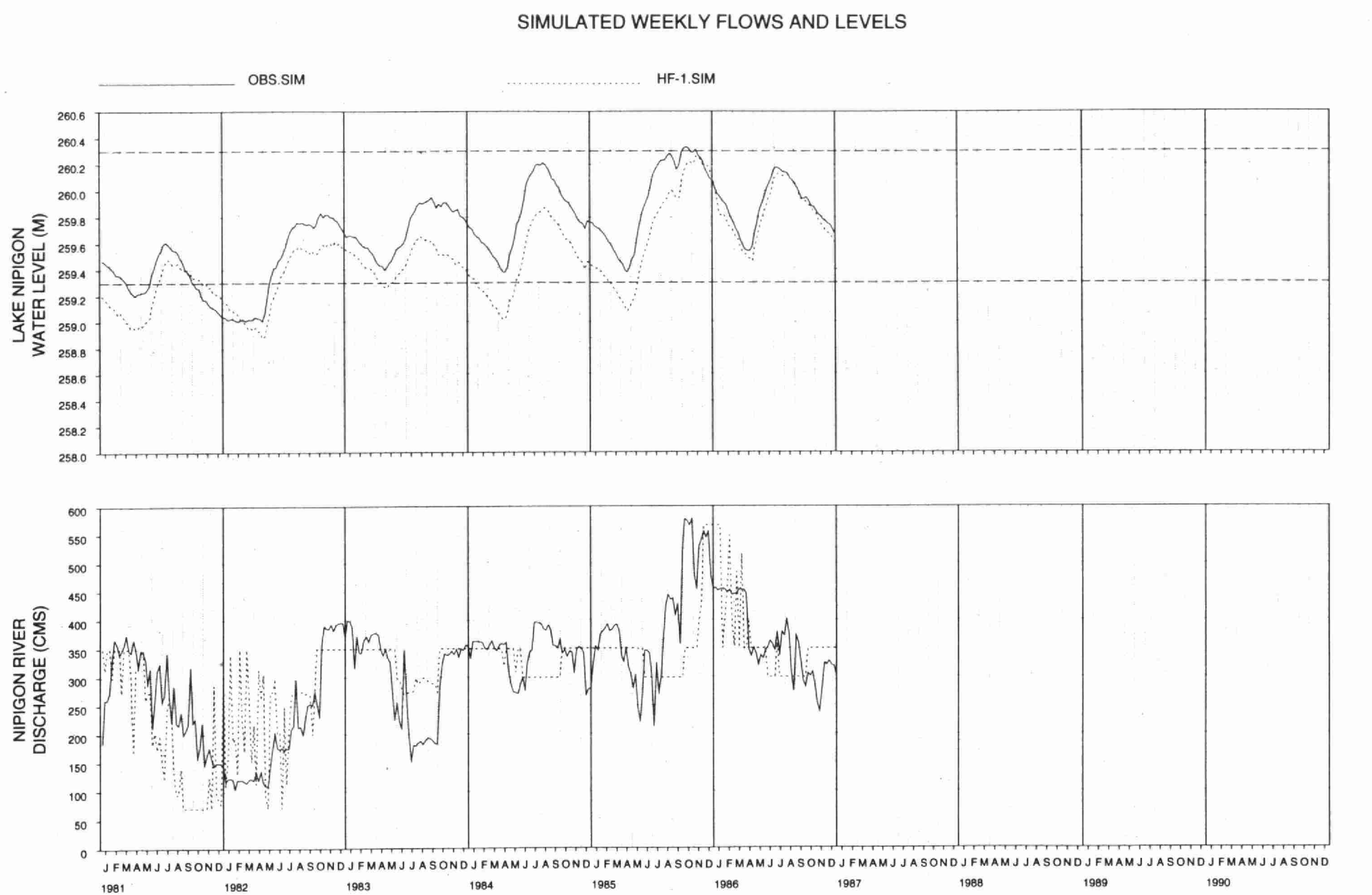


14 MAR 1994 15 : 51





SIMULATED WEEKLY FLOWS AND LEVELS
OBS.SIM
HF-1.SIM
LAKE NIPIGON WATER LEVEL (M)
260.6
260.4
260.2
260.0
259.8
259.6
259.4
259.2
259.0
258.8
258.6
258.4
258.2
258.0
NIPIGON RIVER DISCHARGE (CMS)
600
550
500
450
400
350
300
250
200
150
100
50
0
J F M A M J J A S O N D
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980



SIMULATED WEEKLY FLOWS AND LEVELS
OBS.SIM
HF-1.SIM
LAKE NIPIGON WATER LEVEL (M)
260.6
260.4
260.2
260.0
259.8
259.6
259.4
259.2
259.0
258.8
258.6
258.4
258.2
258.0
NIPIGON RIVER DISCHARGE (CMS)
600
550
500
450
400
350
300
250
200
150
100
50
0
J F M A M J J A S O N D
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990

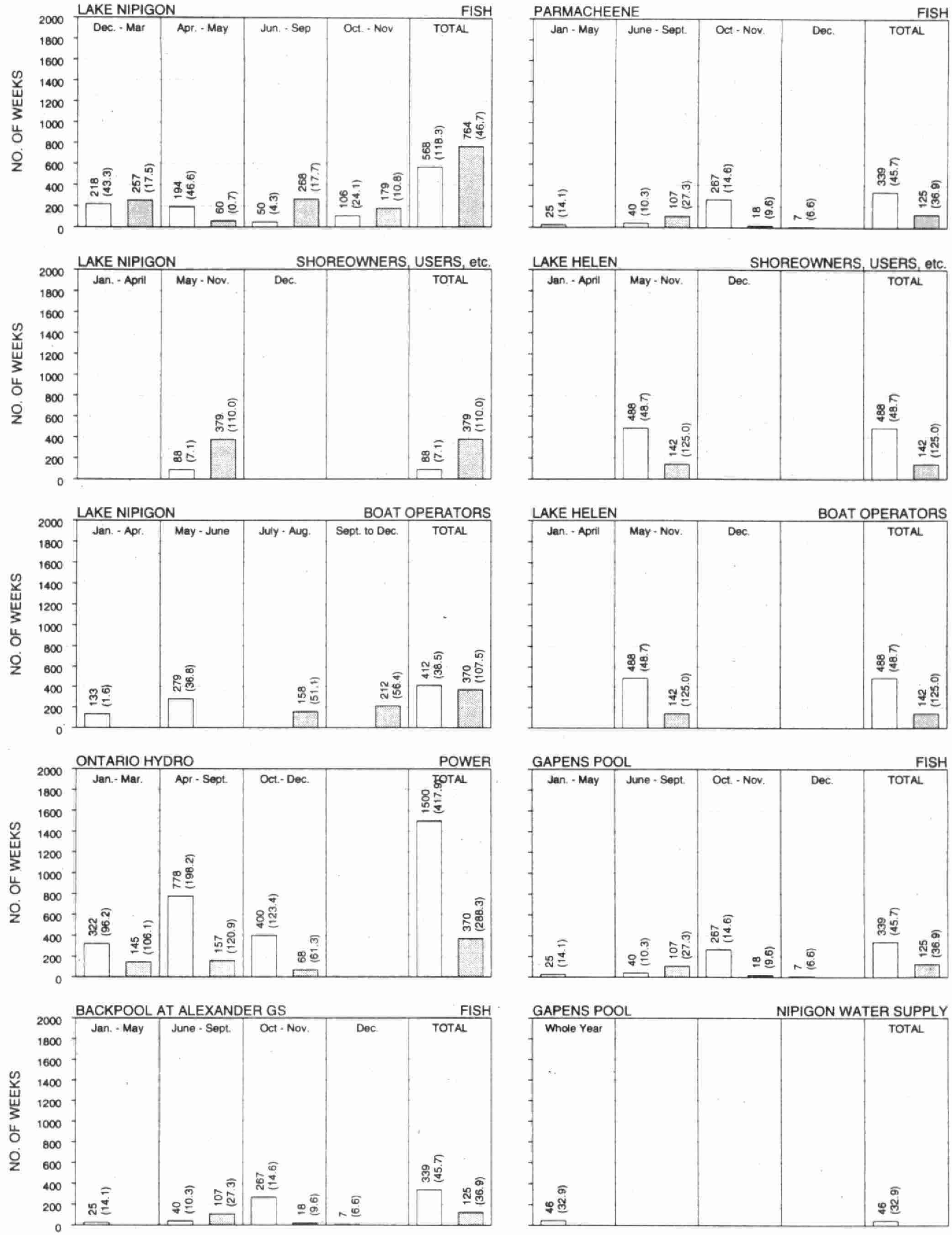
HF-1.SIM

CASE:-33% HYDRO, 33% LAKE NIPIGON FISH, 33% NI

TOTAL 1872 WEEKS

☐ AVERAGE LEVEL OR FLOW BELOW THE EXPECTED RANGE

▨ AVERAGE LEVEL OR FLOW ABOVE THE EXPECTED RANGE



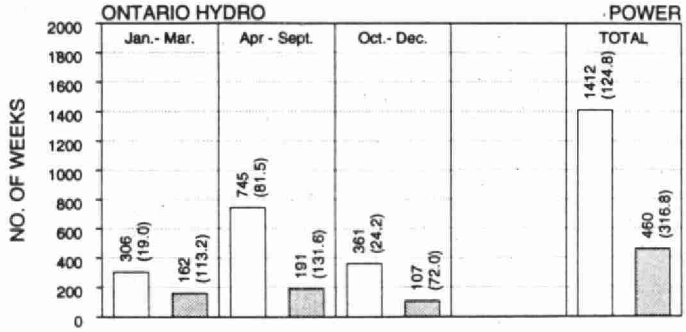
HF-1.SIM

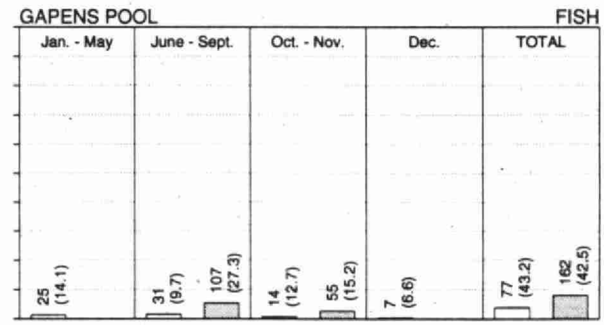
CASE:-33% HYDRO, 33% LAKE NIPIGON FISH, 33% NI

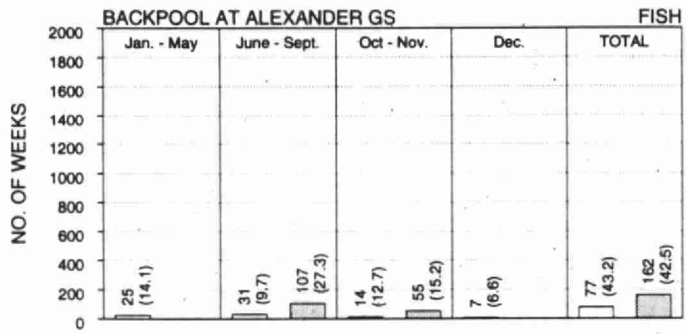
TOTAL 1872 WEEKS

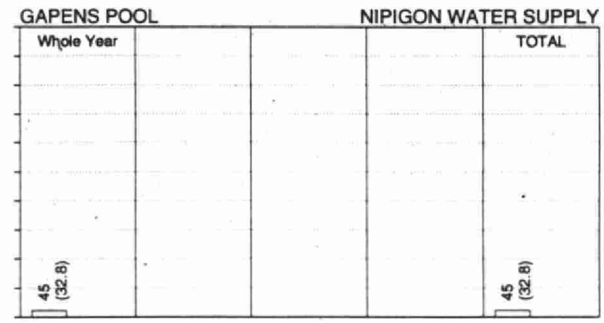
☐ MAXIMUM FLOW BELOW THE EXPECTED RANGE

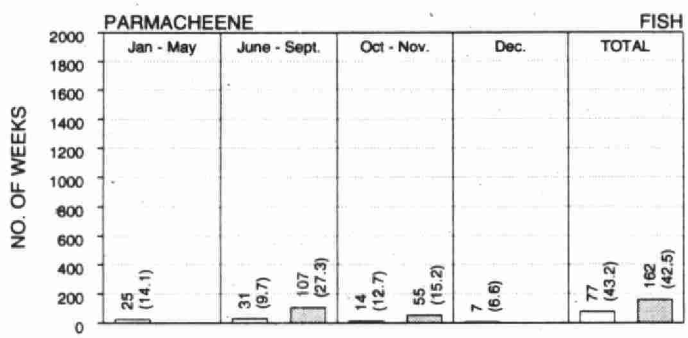
▨ MAXIMUM FLOW ABOVE THE EXPECTED RANGE

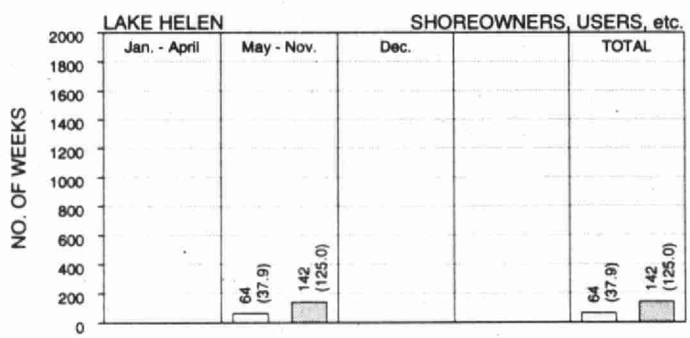


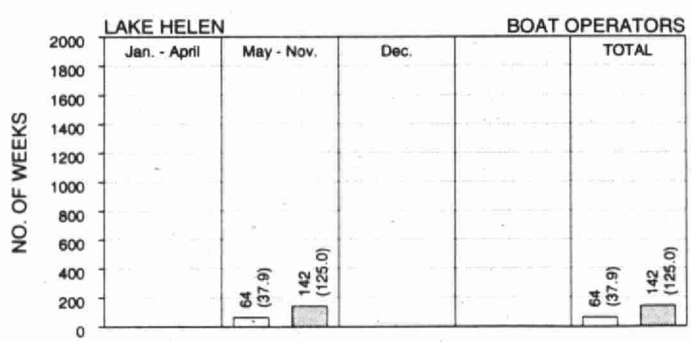










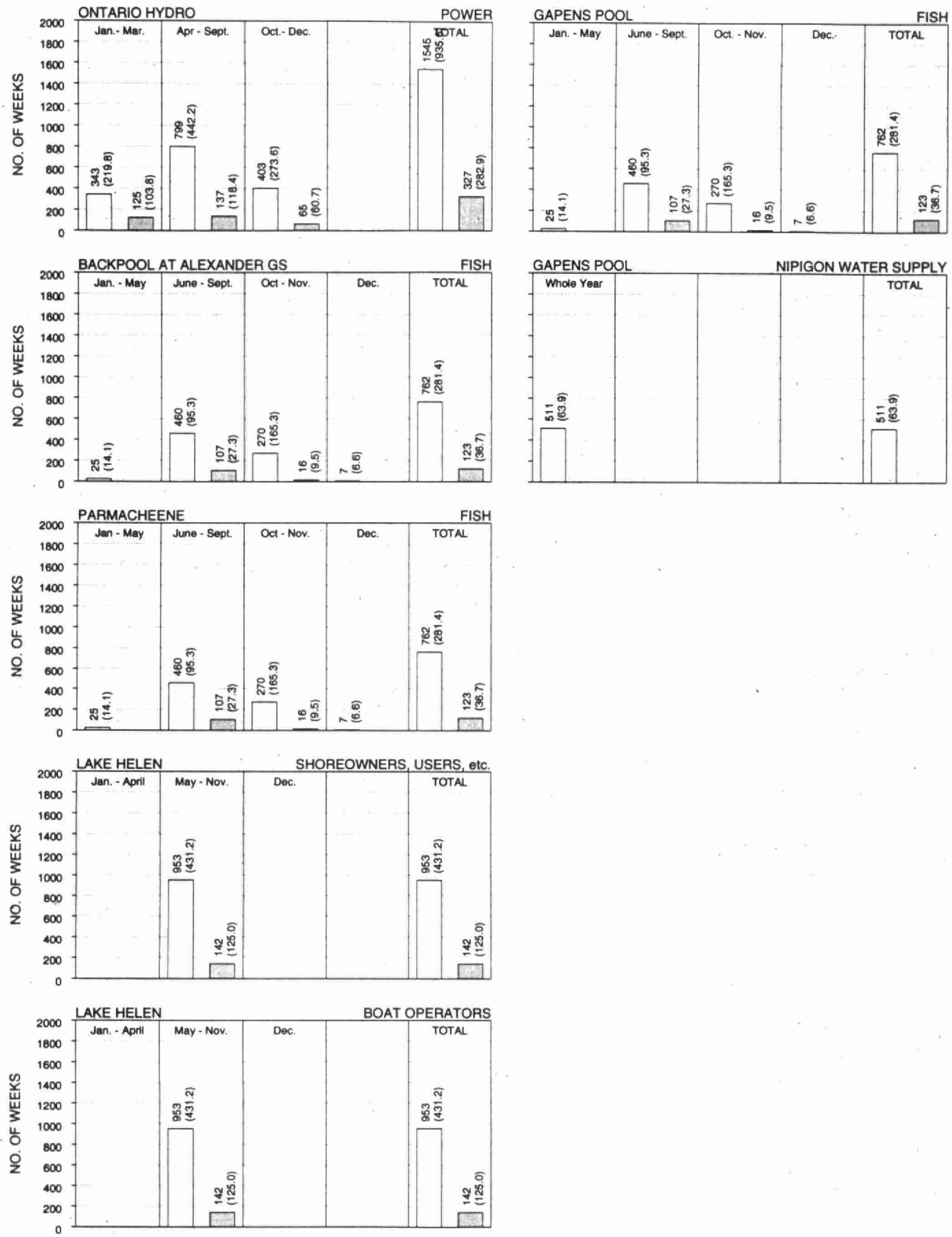


HF-1.SIM

CASE:-33% HYDRO, 33% LAKE NIPIGON FISH, 33% NI

TOTAL 1872 WEEKS

MINIMUM FLOW BELOW THE EXPECTED RANGE
MINIMUM FLOW ABOVE THE EXPECTED RANGE



HF-1.SIM
CASE:-33% HYDRO, 33% LAKE NIPIGON FISH, 33% NI

INCREMENTAL CHANGE

FROM:	0	42	260.12	TO:	1	15	259.47	0.65
FROM:	1	39	259.81	TO:	2	16	259.04	0.77
FROM:	2	39	259.99	TO:	3	15	259.49	0.50
FROM:	3	39	260.09	TO:	4	15	259.49	0.60
FROM:	4	39	260.03	TO:	5	17	259.42	0.61
FROM:	5	39	259.99	TO:	6	15	259.43	0.56
FROM:	6	39	260.04	TO:	7	14	259.46	0.58
FROM:	7	43	260.19	TO:	8	17	259.40	0.79
FROM:	8	39	260.09	TO:	9	14	259.48	0.61
FROM:	9	39	259.68	TO:	10	14	259.06	0.62
FROM:	10	40	259.88	TO:	11	16	259.22	0.66
FROM:	11	39	259.87	TO:	12	16	259.18	0.69
FROM:	12	39	260.01	TO:	13	15	259.36	0.65
FROM:	13	40	260.39	TO:	14	16	259.44	0.95
FROM:	14	41	259.90	TO:	15	14	259.51	0.39
FROM:	15	39	260.02	TO:	16	14	259.36	0.66
FROM:	16	39	259.89	TO:	17	10	259.29	0.60
FROM:	17	46	260.25	TO:	18	15	259.49	0.76
FROM:	18	40	260.29	TO:	19	16	259.42	0.87
FROM:	19	44	260.47	TO:	20	14	259.61	0.86
FROM:	20	45	260.30	TO:	21	16	259.50	0.80
FROM:	21	39	259.75	TO:	22	14	259.13	0.62
FROM:	22	44	259.70	TO:	23	16	259.21	0.49
FROM:	23	45	260.19	TO:	24	17	259.40	0.79
FROM:	24	39	259.95	TO:	25	14	259.25	0.70
FROM:	25	39	259.46	TO:	26	14	258.94	0.52
FROM:	26	44	260.01	TO:	27	17	259.40	0.61
FROM:	27	39	260.06	TO:	28	15	259.31	0.75
FROM:	28	39	259.78	TO:	29	16	259.25	0.53
FROM:	29	39	259.46	TO:	30	14	258.95	0.51
FROM:	30	39	259.34	TO:	31	16	258.88	0.46
FROM:	31	44	259.60	TO:	32	17	259.26	0.34
FROM:	32	40	259.52	TO:	33	14	259.02	0.50
FROM:	33	39	259.69	TO:	34	15	259.08	0.61
FROM:	34	44	260.26	TO:	35	16	259.46	0.80

ANNUAL DRAWDOWN (M):
AVERAGE = 0.64
ST.DEV. = 0.14
MAXIMUM = 0.95
MINIMUM = 0.34

MAXIMUM ELEVATION IN FALL (M):
AVERAGE = 259.94
ST.DEV. = 0.28
MAXIMUM = 260.47
MINIMUM = 259.34

MINIMUM ELEVATION IN SPRING (M):
AVERAGE = 259.30
ST.DEV. = 0.19
MAXIMUM = 259.61
MINIMUM = 258.88

MINIMUM OFF PEAK FLOWS
FOR WEEK 23-39 Q= 170.00
THE REST Q= 270.00

		NO. OF WEEKS
NO PEAKING	=	375
PEAKING	=	1497
QON-QOFF > 100 CMS	=	1390
QON-QOFF > 200 CMS	=	54
QON-QOFF > 300 CMS	=	0

**** FOR POWER CALCULATION ****

MINIMUM OFF PEAK FLOWS

FOR WEEK 23-39	Q=	170.00
THE REST	Q=	270.00

		MWh	DOLLARS
ON PEAK	=	51702520.	944861600.
OFF PEAK	=	13328750.	164765500.

ANNUAL AVERAGE

		MWh	DOLLARS
ON PEAK	=	1436181.	26246150.
OFF PEAK	=	370243.	4576820.
		1977	1981-82
ON PEAK	=	7006584.	5476623.
OFF PEAK	=	3995765.	7547898.

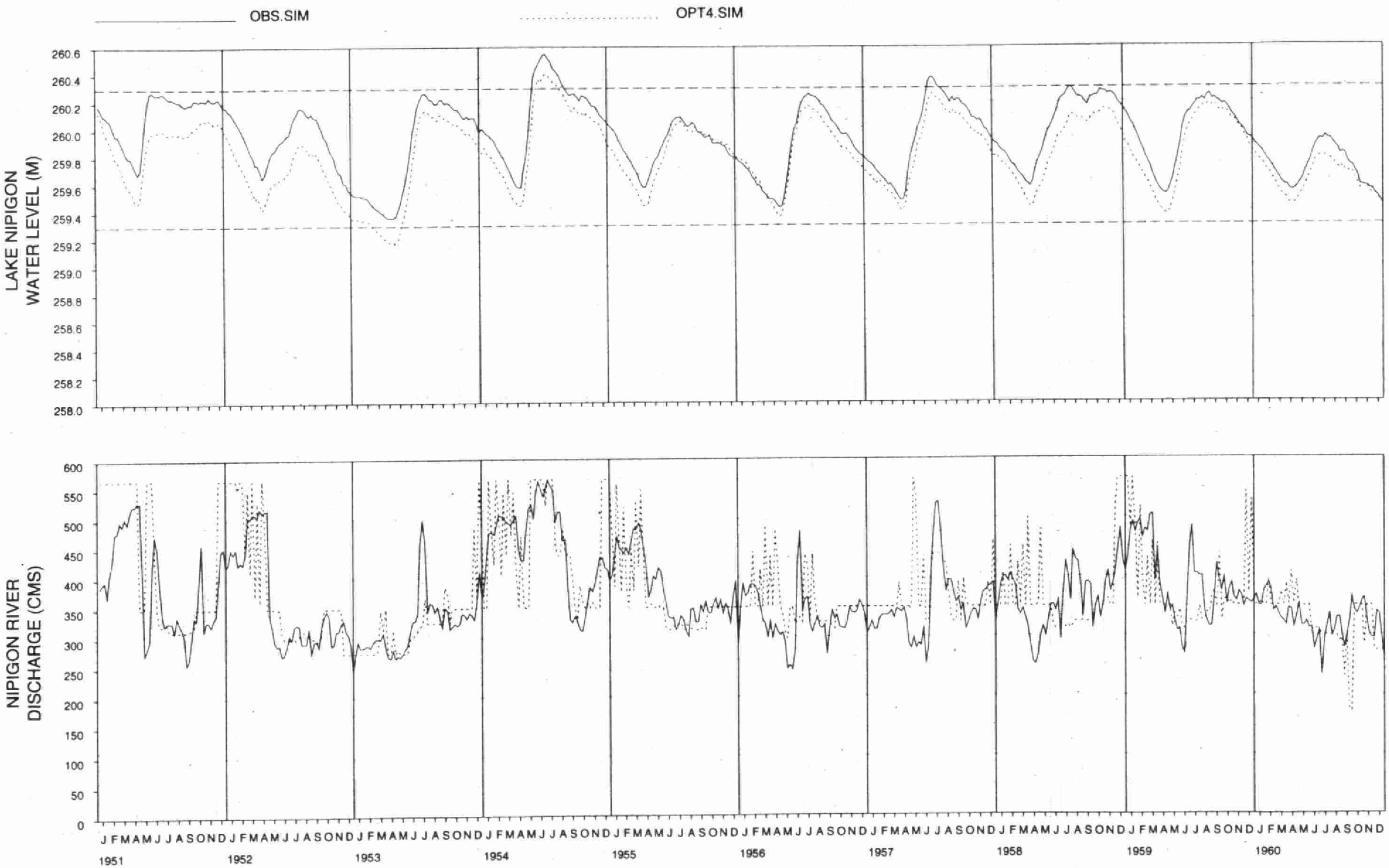
ANNUAL POWER .

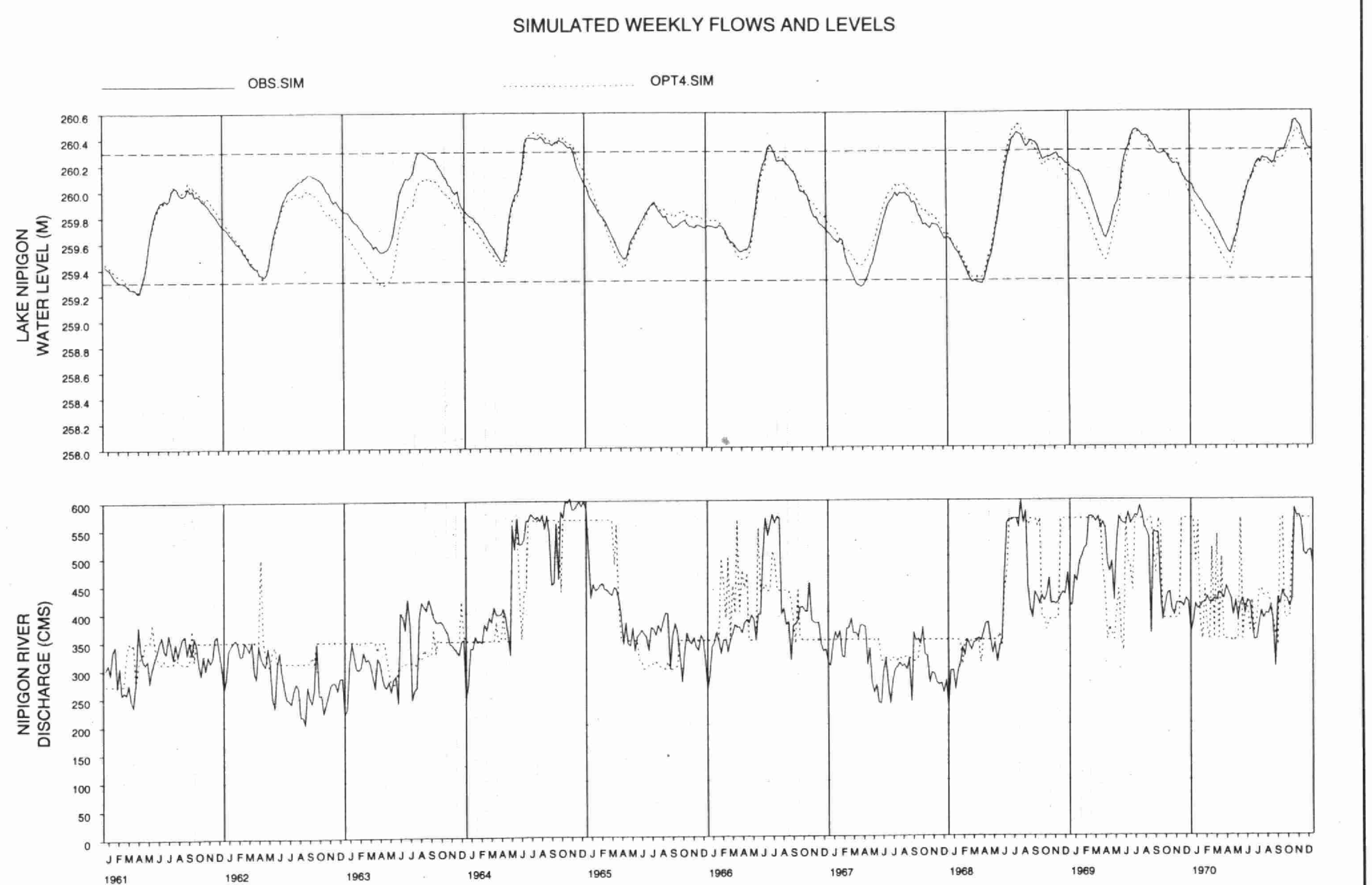
YEAR	ON PEAK MWH	OFF PEAK MWH	TOTAL MWH	ON PEAK $	OFF PEAK $	TOTAL $
1951	1709233.	213048.	1922281.	31537670.	2260852.	33798520.
1952	1518332.	331583.	1849915.	28218790.	3786991.	32005780.
1953	1330723.	425680.	1756404.	24303490.	5372201.	29675690.
1954	1788810.	217842.	2006652.	32531710.	2809724.	35341430.
1955	1433447.	398501.	1831948.	26400700.	4823891.	31224590.
1956	1443354.	415808.	1859162.	26312800.	5205789.	31518580.
1957	1525547.	362622.	1888169.	27420390.	4821756.	32242140.
1958	1454802.	377214.	1832016.	26470220.	4634924.	31105140.
1959	1480036.	420025.	1900061.	27311040.	5059859.	32370900.
1960	1359593.	426370.	1785963.	24742840.	5379307.	30122150.
1961	1359700.	425680.	1785380.	24745180.	5372201.	30117380.
1962	1359700.	425680.	1785380.	24745180.	5372201.	30117380.
1963	1342935.	425680.	1768615.	24489000.	5372201.	29861200.
1964	1804337.	210840.	2015177.	32456000.	2807009.	35263010.
1965	1514553.	326194.	1840747.	28233770.	3661033.	31894800.
1966	1676927.	292423.	1969350.	30431060.	3774225.	34205290.
1967	1359700.	425680.	1785380.	24745180.	5372201.	30117380.
1968	1672116.	295044.	1967160.	30212220.	3808493.	34020710.
1969	1900110.	145573.	2045684.	34967640.	1474531.	36442180.
1970	1747443.	246292.	1993735.	31896250.	2918695.	34814950.
1971	1812994.	150748.	1963742.	33234260.	1595992.	34830260.
1972	1587255.	276658.	1863913.	29495400.	3066073.	32561470.
1973	1357113.	425680.	1782793.	24706500.	5372201.	30078700.
1974	1471481.	375972.	1847453.	26747060.	4623602.	31370660.
1975	1489341.	348320.	1837660.	27669320.	4029288.	31698610.
1976	1097875.	460245.	1558121.	20088210.	5791410.	25879620.
1977	1117848.	509195.	1627043.	19927160.	6532811.	26459970.
1978	1408104.	454181.	1862285.	25657900.	5755034.	31412940.
1979	1359700.	425680.	1785380.	24745180.	5372201.	30117380.
1980	1229477.	427060.	1656537.	22393350.	5385724.	27779080.
1981	590882.	510644.	1101526.	11396460.	6145027.	17541480.
1982	820355.	554902.	1375257.	14629660.	7214438.	21844100.
1983	1330723.	425680.	1756403.	24283880.	5372201.	29656080.
1984	1352145.	425680.	1777826.	24626380.	5372201.	29998580.
1985	1431802.	384941.	1816743.	26050720.	4727908.	30778630.
1986	1463478.	365347.	1828825.	27040870.	4320873.	31361740.

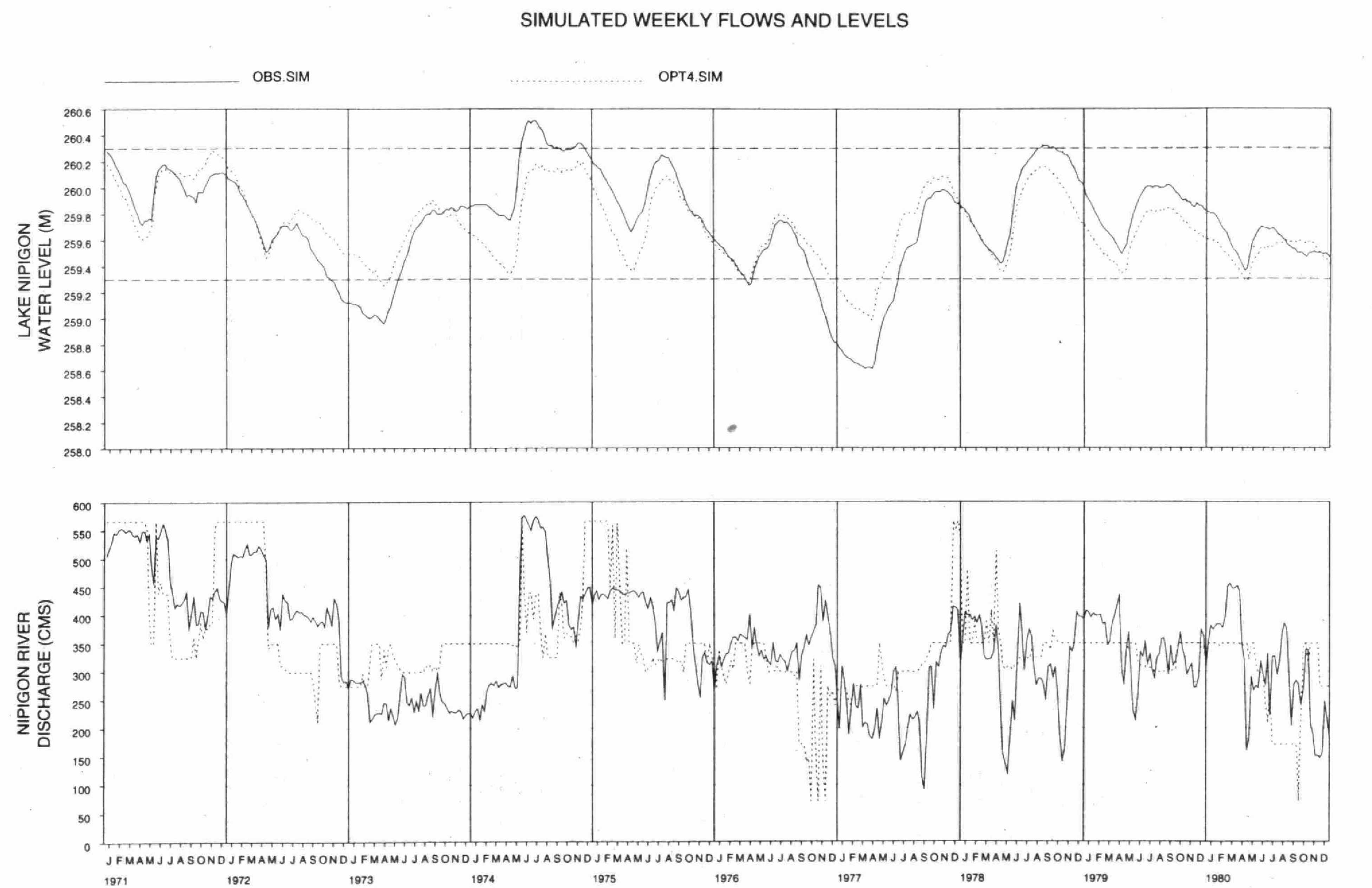
Option OPT4

- Time series of simulated average weekly Lake Nipigon water levels and Nipigon River flows (1951-86)
- Performance of average Lake Nipigon level and Nipigon River flow and minimum and maximum flows relative to penalty functions
- Lake Nipigon water level data: fall to spring drawdown; maximum fall; minimum spring; peaking data
- Power produced and dollar value

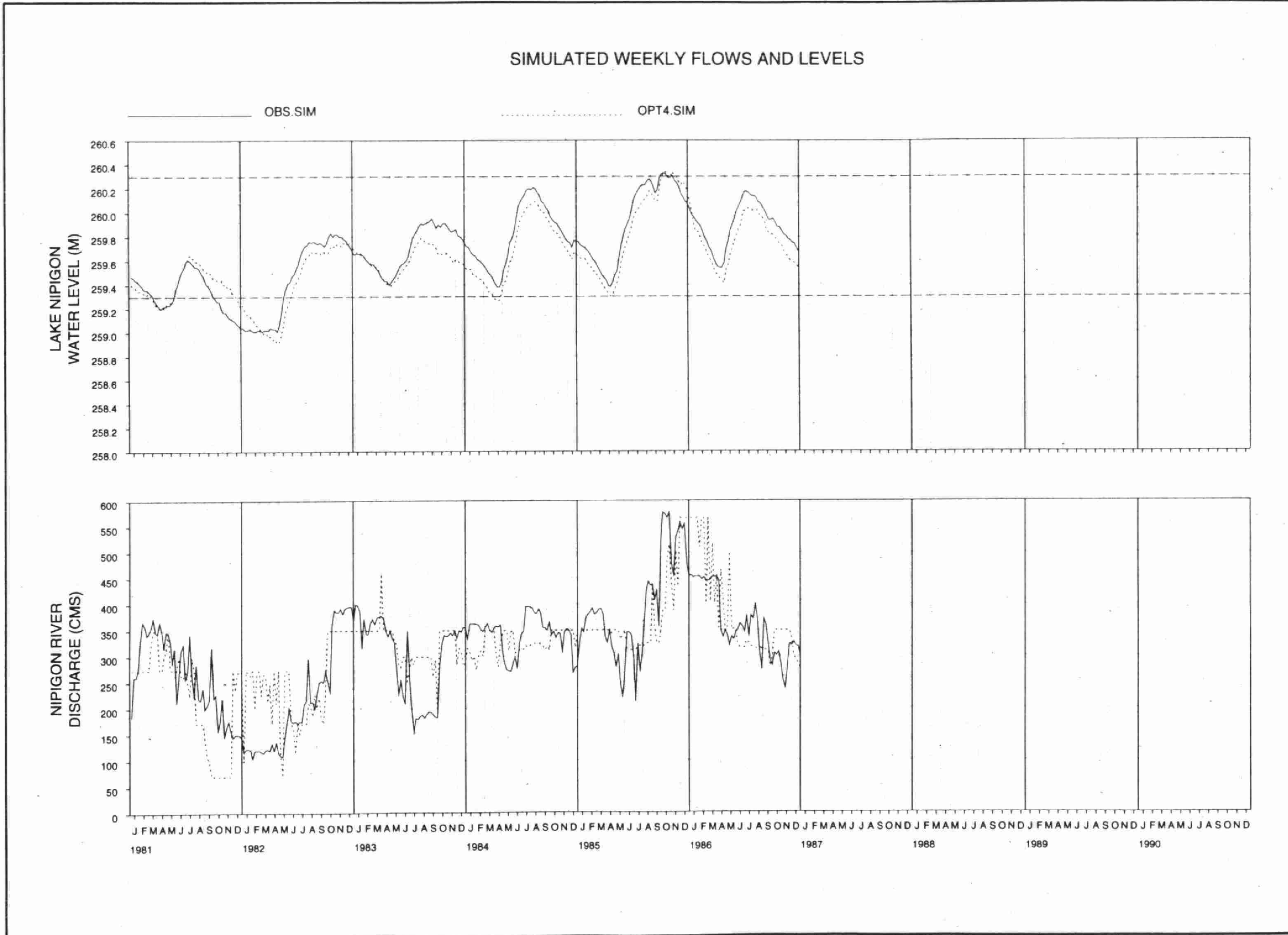
SIMULATED WEEKLY FLOWS AND LEVELS

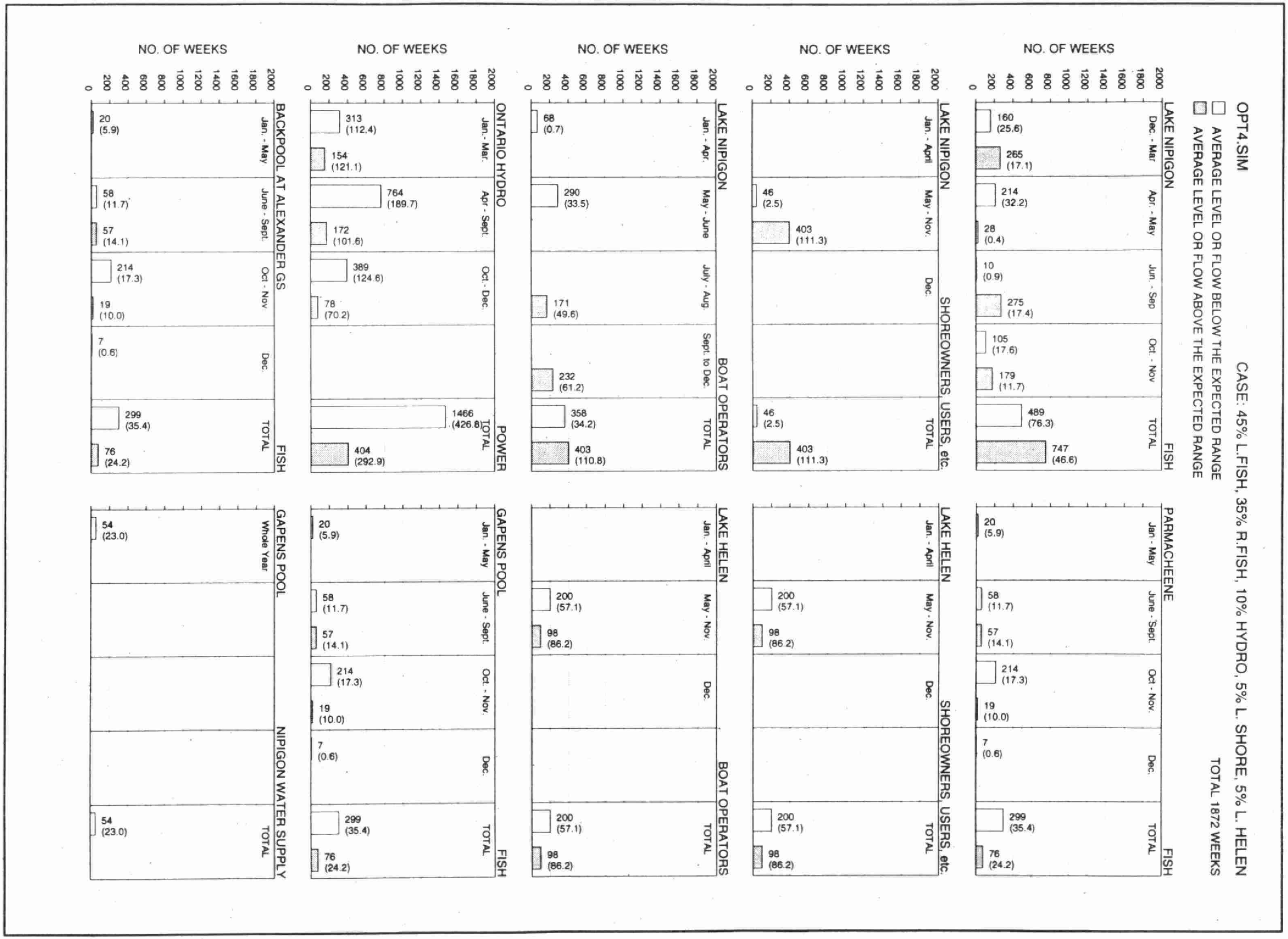



SIMULATED WEEKLY FLOWS AND LEVELS
OBS.SIM
OPT4.SIM
LAKE NIPIGON WATER LEVEL (M)
260.6
260.4
260.2
260.0
259.8
259.6
259.4
259.2
259.0
258.8
258.6
258.4
258.2
258.0
NIPIGON RIVER DISCHARGE (CMS)
600
550
500
450
400
350
300
250
200
150
100
50
0
J F M A M J J A S O N D
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970



SIMULATED WEEKLY FLOWS AND LEVELS
OBS.SIM
OPT4.SIM
LAKE NIPIGON WATER LEVEL (M)
260.6
260.4
260.2
260.0
259.8
259.6
259.4
259.2
259.0
258.8
258.6
258.4
258.2
258.0
NIPIGON RIVER DISCHARGE (CMS)
600
550
500
450
400
350
300
250
200
150
100
50
0
J F M A M J J A S O N D
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980


SIMULATED WEEKLY FLOWS AND LEVELS
OBS.SIM
OPT4.SIM
LAKE NIPIGON WATER LEVEL (M)
260.6
260.4
260.2
260.0
259.8
259.6
259.4
259.2
259.0
258.8
258.6
258.4
258.2
258.0
NIPIGON RIVER DISCHARGE (CMS)
600
550
500
450
400
350
300
250
200
150
100
50
0
J F M A M J J A S O N D
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990



OPT4.SIM
CASE: 45% L.FISH, 35% R.FISH, 10% HYDRO, 5% L. SHORE, 5% L. HELEN
AVERAGE LEVEL OR FLOW BELOW THE EXPECTED RANGE
AVERAGE LEVEL OR FLOW ABOVE THE EXPECTED RANGE
TOTAL 1872 WEEKS
NO. OF WEEKS
0 200 400 600 800 1000 1200 1400 1600 1800 2000
LAKE NIPIGON FISH
Dec. - Mar 160 (25.6) 265 (17.1)
Apr. - May 214 (32.2) 28 (0.4)
Jun. - Sep 10 (0.9) 275 (17.4)
Oct. - Nov 105 (17.6) 179 (11.7)
TOTAL 489 (76.3) 747 (46.6)
PARMACHEENE FISH
Jan - May 20 (5.9)
June - Sept 58 (11.7) 57 (14.1)
Oct - Nov. 214 (17.3) 19 (10.0)
Dec. 7 (0.6)
TOTAL 299 (35.4) 76 (24.2)
LAKE NIPIGON SHOREOWNERS, USERS, etc.
Jan. - April
May - Nov. 46 (2.5) 403 (111.3)
Dec.
TOTAL 46 (2.5) 403 (111.3)
LAKE HELEN SHOREOWNERS, USERS, etc.
Jan. - April
May - Nov. 200 (57.1) 98 (86.2)
Dec.
TOTAL 200 (57.1) 98 (86.2)
LAKE NIPIGON BOAT OPERATORS
Jan. - Apr. 68 (0.7)
May - June 290 (33.5)
July - Aug. 171 (49.6)
Sept. to Dec. 232 (61.2)
TOTAL 358 (34.2) 403 (110.8)
LAKE HELEN BOAT OPERATORS
Jan. - April
May - Nov. 200 (57.1) 98 (86.2)
Dec.
TOTAL 200 (57.1) 98 (86.2)
ONTARIO HYDRO POWER
Jan.- Mar. 313 (112.4) 154 (121.1)
Apr. - Sept. 764 (189.7) 172 (101.6)
Oct. - Dec. 389 (124.6) 78 (70.2)
TOTAL 1466 (426.8) 404 (292.9)
GAPENS POOL FISH
Jan. - May 20 (5.9)
June - Sept. 58 (11.7) 57 (14.1)
Oct. - Nov. 214 (17.3) 19 (10.0)
Dec. 7 (0.6)
TOTAL 299 (35.4) 76 (24.2)
BACKPOOL AT ALEXANDER GS FISH
Jan. - May 20 (5.9)
June - Sept. 58 (11.7) 57 (14.1)
Oct. - Nov 214 (17.3) 19 (10.0)
Dec. 7 (0.6)
TOTAL 299 (35.4) 76 (24.2)
GAPENS POOL NIPIGON WATER SUPPLY
Whole Year 54 (23.0)
TOTAL 54 (23.0)

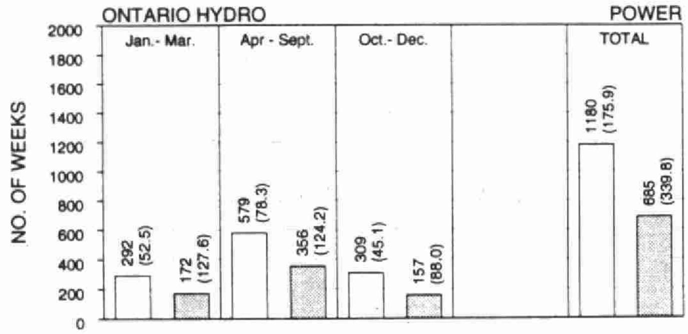
OPT4.SIM

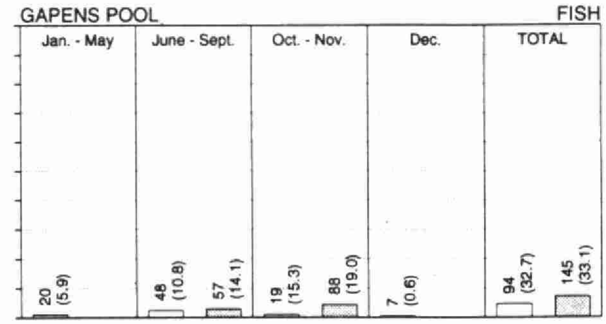
CASE: 45% L.FISH, 35% R.FISH, 10% HYDRO, 5% L. SHORE, 5% L. HELEN

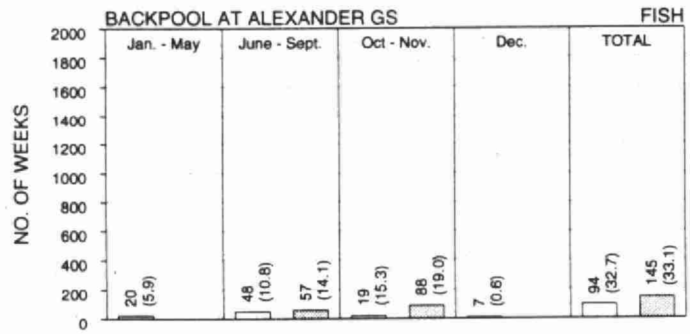
TOTAL 1872 WEEKS

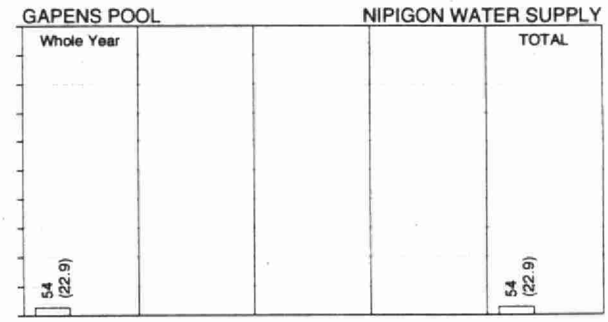
☐ MAXIMUM FLOW BELOW THE EXPECTED RANGE

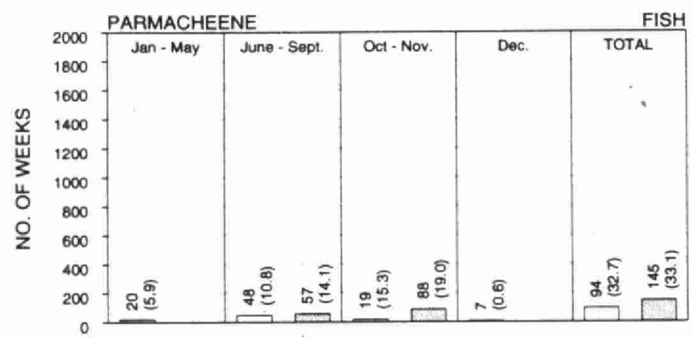
▨ MAXIMUM FLOW ABOVE THE EXPECTED RANGE

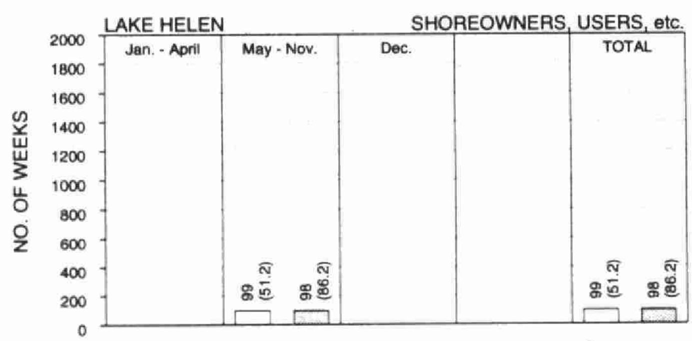


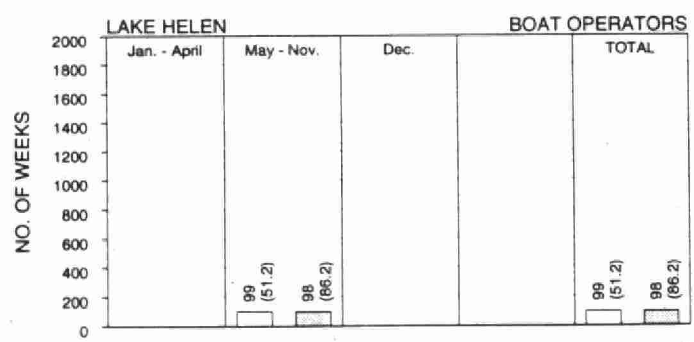












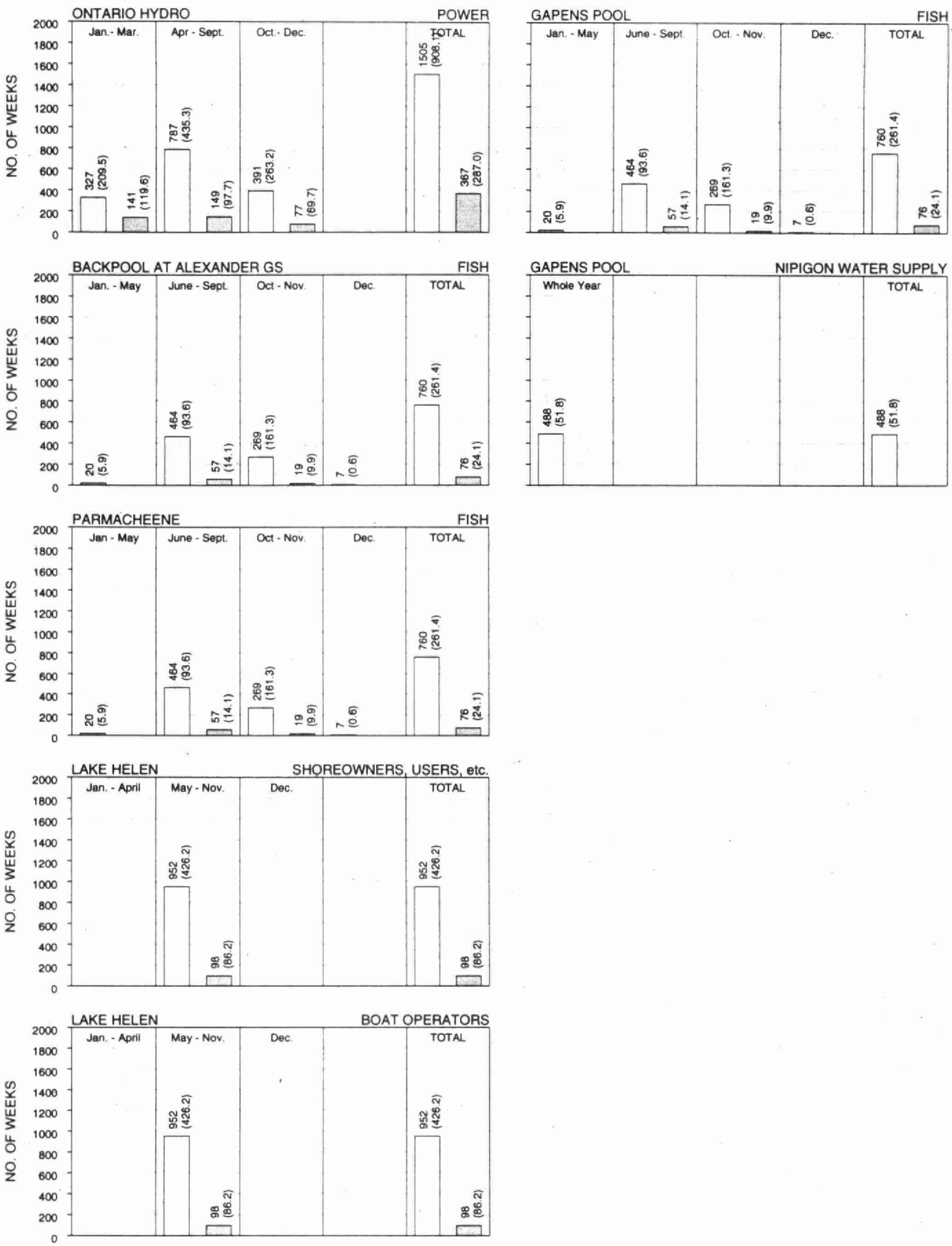
OPT4.SIM

CASE: 45% L.FISH, 35% R.FISH, 10% HYDRO, 5% L. SHORE, 5% L. HELEN

☐ MINIMUM FLOW BELOW THE EXPECTED RANGE

▨ MINIMUM FLOW ABOVE THE EXPECTED RANGE

TOTAL 1872 WEEKS



OPT4.SIM
CASE: 45% L.FISH, 35% R.FISH, 10% HYDRO, 5% L. SHORE, 5% L. HELEN

INCREMENTAL CHANGE

FROM:	0	43	260.08	TO:	1	15	259.42	0.66
FROM:	1	39	259.75	TO:	2	15	259.17	0.58
FROM:	2	39	260.07	TO:	3	15	259.44	0.63
FROM:	3	39	260.14	TO:	4	15	259.44	0.70
FROM:	4	39	259.96	TO:	5	17	259.36	0.60
FROM:	5	39	259.96	TO:	6	15	259.40	0.56
FROM:	6	39	260.08	TO:	7	14	259.43	0.65
FROM:	7	43	260.14	TO:	8	17	259.37	0.77
FROM:	8	39	260.13	TO:	9	14	259.44	0.69
FROM:	9	39	259.67	TO:	10	14	259.23	0.44
FROM:	10	40	260.01	TO:	11	16	259.33	0.68
FROM:	11	39	259.97	TO:	12	16	259.27	0.70
FROM:	12	39	260.07	TO:	13	15	259.41	0.66
FROM:	13	40	260.41	TO:	14	16	259.40	1.01
FROM:	14	41	259.85	TO:	15	14	259.46	0.39
FROM:	15	39	260.07	TO:	16	14	259.41	0.66
FROM:	16	39	259.90	TO:	17	10	259.32	0.58
FROM:	17	46	260.24	TO:	18	15	259.45	0.79
FROM:	18	40	260.28	TO:	19	16	259.38	0.90
FROM:	19	44	260.46	TO:	20	14	259.61	0.85
FROM:	20	45	260.29	TO:	21	16	259.46	0.83
FROM:	21	39	259.73	TO:	22	14	259.25	0.48
FROM:	22	44	259.83	TO:	23	16	259.34	0.49
FROM:	23	45	260.20	TO:	24	17	259.36	0.84
FROM:	24	39	259.89	TO:	25	14	259.27	0.62
FROM:	25	39	259.56	TO:	26	14	258.98	0.58
FROM:	26	44	260.09	TO:	27	17	259.35	0.74
FROM:	27	39	260.09	TO:	28	15	259.34	0.75
FROM:	28	39	259.80	TO:	29	16	259.28	0.52
FROM:	29	39	259.59	TO:	30	14	259.20	0.39
FROM:	30	39	259.46	TO:	31	16	258.91	0.55
FROM:	31	44	259.74	TO:	32	17	259.39	0.35
FROM:	32	40	259.66	TO:	33	14	259.26	0.40
FROM:	33	39	259.90	TO:	34	15	259.30	0.60
FROM:	34	41	260.34	TO:	35	16	259.41	0.93

ANNUAL DRAWDOWN (M):
AVERAGE = 0.64
ST.DEV. = 0.16
MAXIMUM = 1.01
MINIMUM = 0.35

MAXIMUM ELEVATION IN FALL (M):
AVERAGE = 259.98
ST.DEV. = 0.25
MAXIMUM = 260.46
MINIMUM = 259.46

MINIMUM ELEVATION IN SPRING (M):
AVERAGE = 259.34
ST.DEV. = 0.13
MAXIMUM = 259.61
MINIMUM = 258.91

MINIMUM OFF PEAK FLOWS
FOR WEEK 23-39 Q= 170.00
THE REST Q= 270.00

		NO. OF WEEKS
NO PEAKING	=	365
PEAKING	=	1506
QON-QOFF > 100 CMS	=	1181
QON-QOFF > 200 CMS	=	326
QON-QOFF > 300 CMS	=	0

**** FOR POWER CALCULATION ****
MINIMUM OFF PEAK FLOWS
FOR WEEK 23-39 Q= 170.00
THE REST Q= 270.00

		MWh	DOLLARS
ON PEAK	=	51024240.	930648500.
OFF PEAK	=	13660650.	168095500.

ANNUAL AVERAGE

		MWh	DOLLARS
ON PEAK	=	1417340.	25851350.
OFF PEAK	=	379462.	4669319.
		1977	1981-82
ON PEAK	=	5981451.	6356206.
OFF PEAK	=	4641003.	9050789.

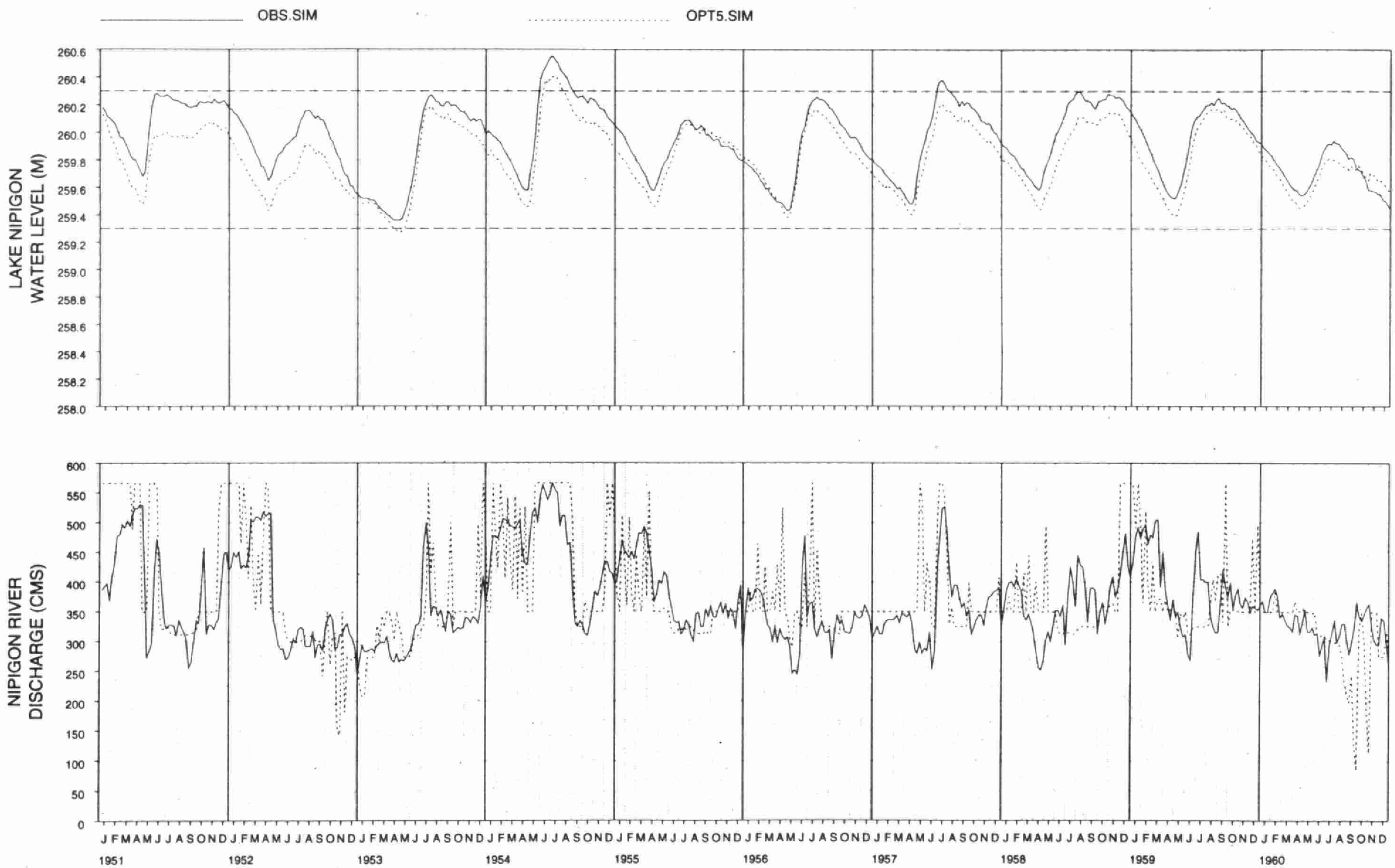
ANNUAL POWER

YEAR	ON PEAK MWH	OFF PEAK MWH	TOTAL MWH	ON PEAK $	OFF PEAK $	TOTAL $
1951	1718278.	215635.	1933913.	31696120.	2301976.	33998100.
1952	1495108.	320454.	1815563.	27673180.	3757771.	31430950.
1953	1269210.	405604.	1674814.	22876320.	5014526.	27890850.
1954	1762766.	267244.	2030011.	31937140.	3372353.	35309490.
1955	1505684.	354895.	1860579.	27643250.	4286963.	31930210.
1956	1410989.	431830.	1842818.	25784610.	5294729.	31079340.
1957	1434080.	466375.	1900456.	25965150.	5752359.	31717500.
1958	1507476.	348409.	1855885.	27450970.	4271771.	31722740.
1959	1497362.	358152.	1855514.	27540340.	4225688.	31766030.
1960	1283406.	430510.	1713916.	23342380.	5429782.	28772160.
1961	1296547.	428061.	1724608.	23271020.	5395527.	28666550.
1962	1382255.	416366.	1798622.	25140030.	5276268.	30416290.
1963	1341357.	431648.	1773005.	24484630.	5453370.	29938000.
1964	1795517.	238426.	2033943.	32328150.	3063403.	35391550.
1965	1555484.	306842.	1862326.	28978580.	3376969.	32355550.
1966	1573543.	419500.	1993043.	28559020.	5120757.	33679770.
1967	1388262.	425680.	1813943.	25236190.	5372201.	30608390.
1968	1668278.	304290.	1972568.	30098910.	3878823.	33977730.
1969	1907235.	158165.	2065400.	35054770.	1640481.	36695250.
1970	1686260.	321069.	2007330.	30850650.	3574181.	34424830.
1971	1748803.	218132.	1966935.	32207980.	2187765.	34395750.
1972	1550561.	267344.	1817905.	28798140.	2970140.	31768280.
1973	1275667.	425680.	1701348.	23002710.	5372201.	28374910.
1974	1454468.	442919.	1897388.	26360180.	5307140.	31667320.
1975	1529449.	313913.	1843363.	28484160.	3514073.	31998230.
1976	956643.	517440.	1474083.	17437730.	6688696.	24126430.
1977	1142111.	493258.	1635369.	20049880.	6600584.	26650460.
1978	1390810.	413158.	1803968.	25359250.	5186299.	30545550.
1979	1363839.	425680.	1789520.	24801040.	5372201.	30173240.
1980	1104562.	427060.	1531622.	20273540.	5385724.	25659270.
1981	716930.	485393.	1202324.	13070090.	6240242.	19310330.
1982	667054.	645696.	1312751.	11965140.	8397377.	20362520.
1983	1302722.	416366.	1719089.	23774520.	5276268.	29050790.
1984	1320331.	425680.	1746011.	23847710.	5372201.	29219910.
1985	1494541.	371803.	1866344.	27110940.	4574141.	31685080.
1986	1526299.	321951.	1848250.	28195210.	3790158.	31985370.

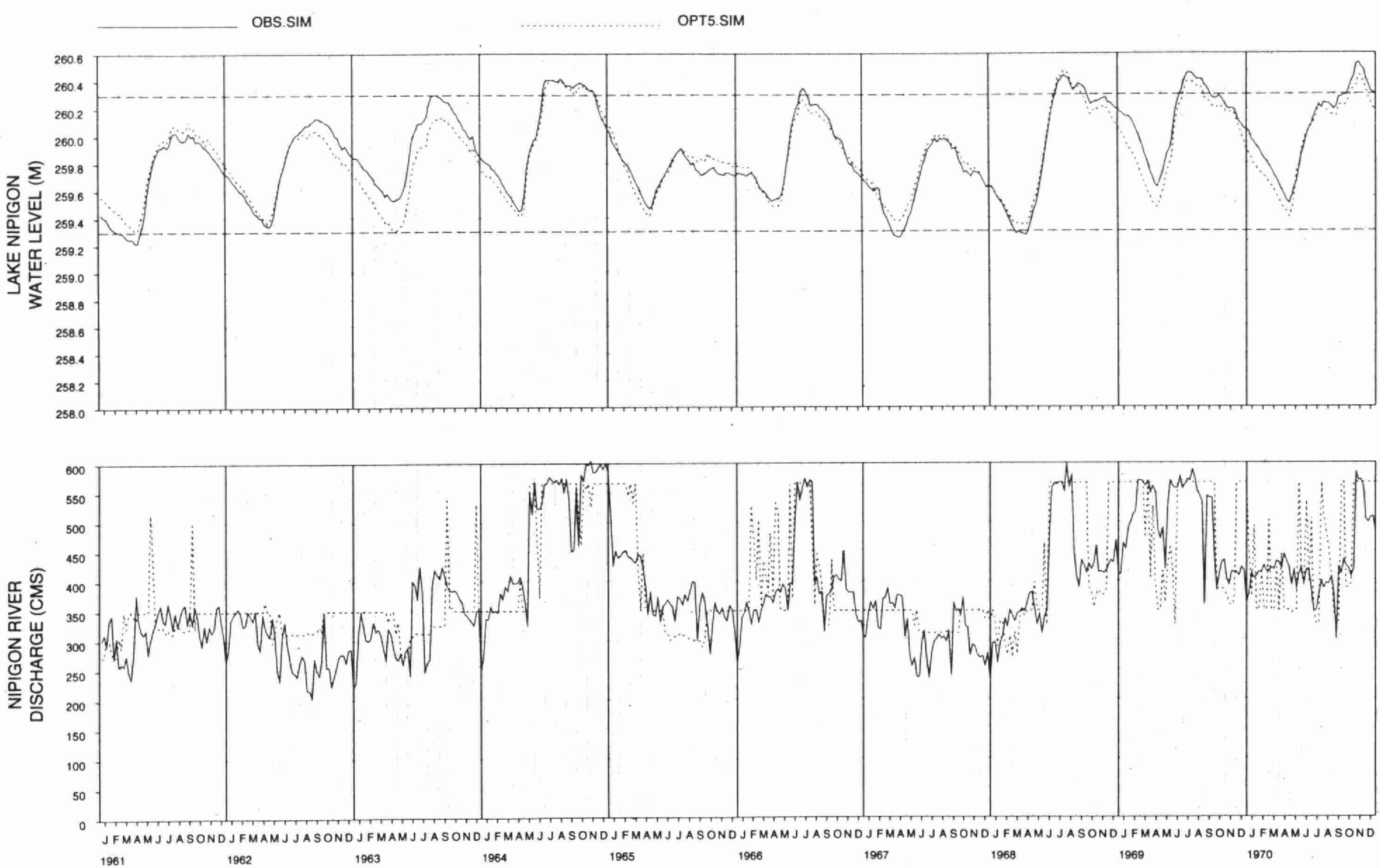
Option OPT5

- Time series of simulated average weekly Lake Nipigon water levels and Nipigon River flows (1951-86)
- Performance of average Lake Nipigon level and Nipigon River flow and minimum and maximum flows relative to penalty functions
- Lake Nipigon water level data: fall to spring drawdown; maximum fall; minimum spring; peaking data
- Power produced and dollar value

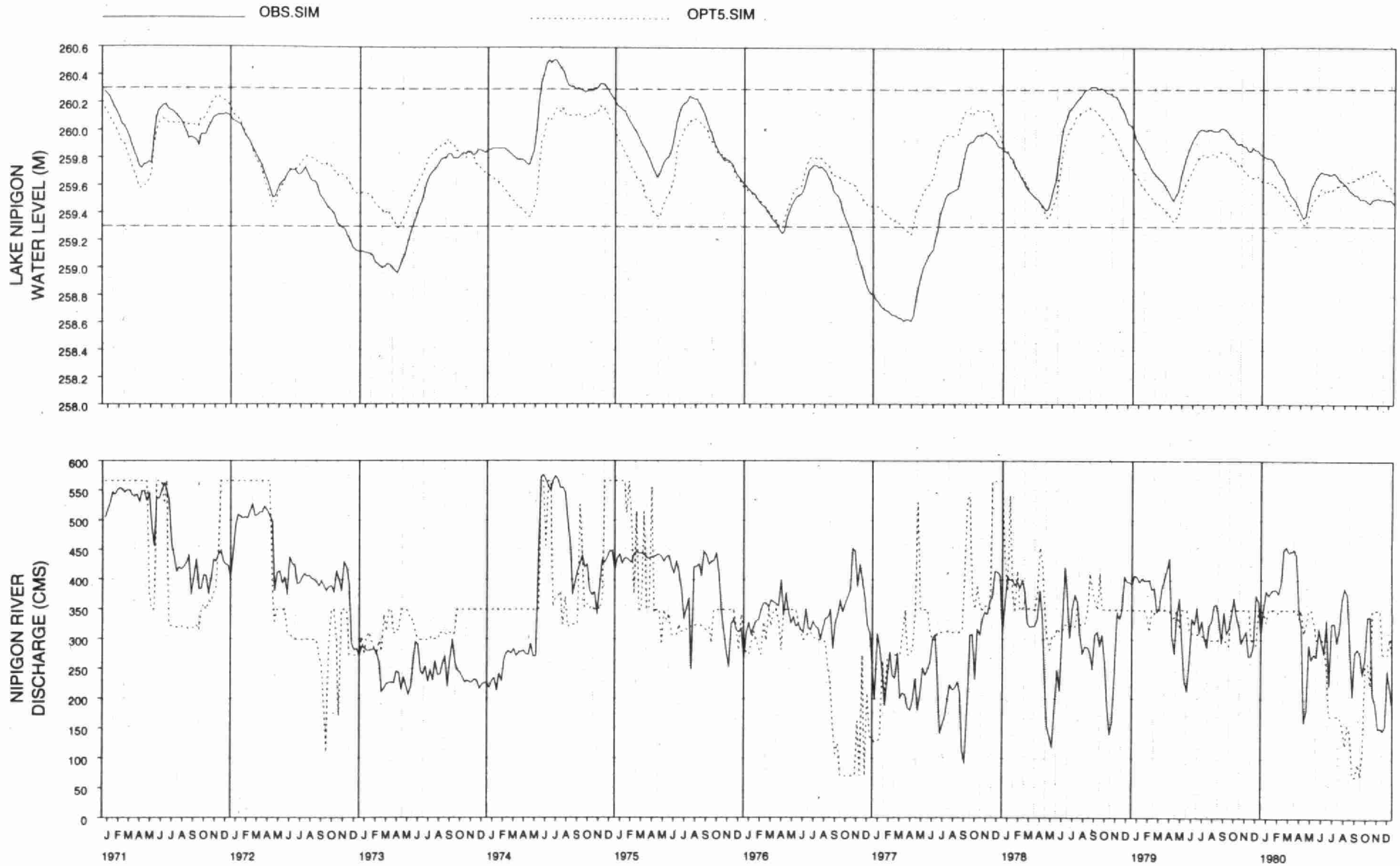
SIMULATED WEEKLY FLOWS AND LEVELS



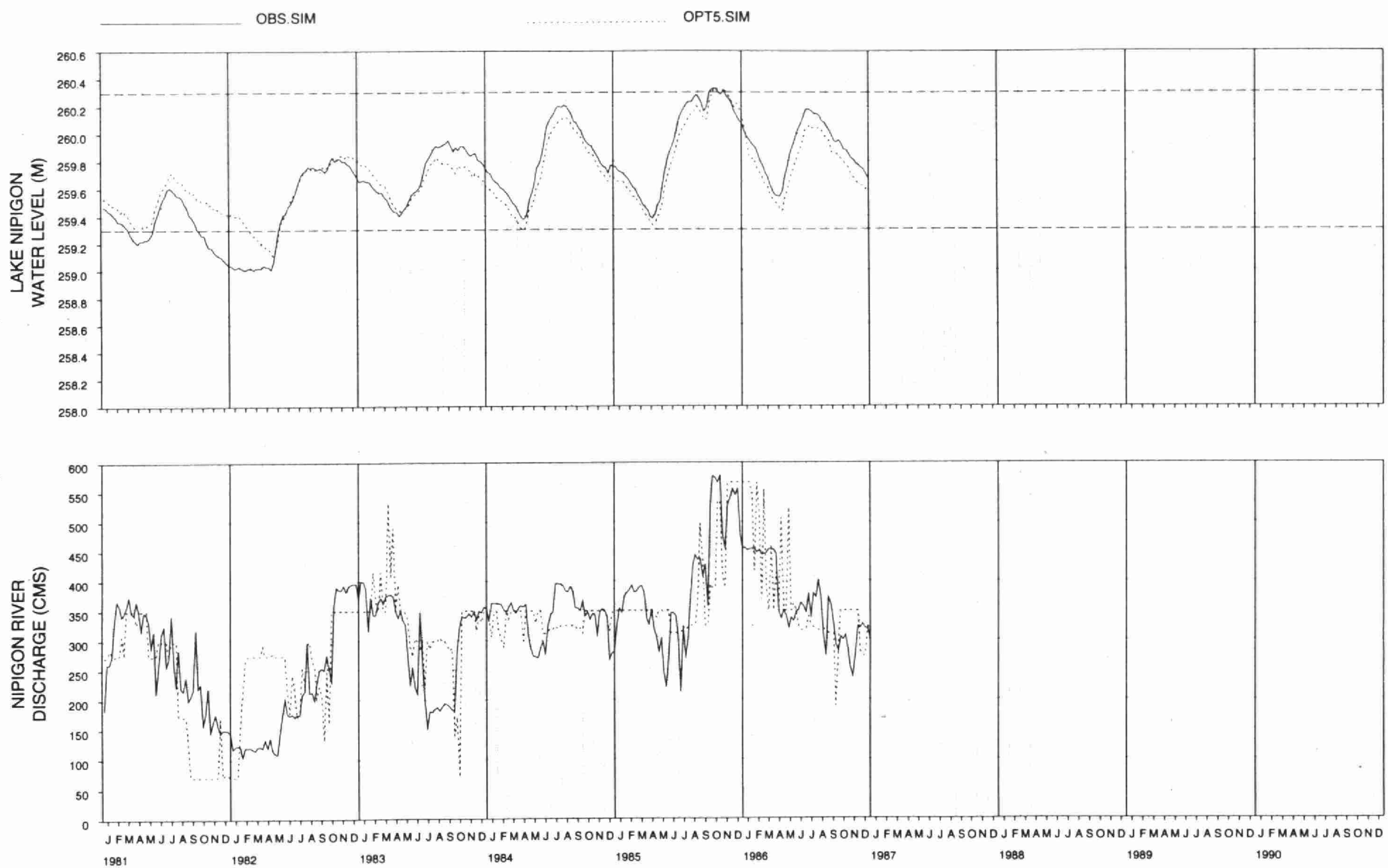
SIMULATED WEEKLY FLOWS AND LEVELS



SIMULATED WEEKLY FLOWS AND LEVELS



SIMULATED WEEKLY FLOWS AND LEVELS

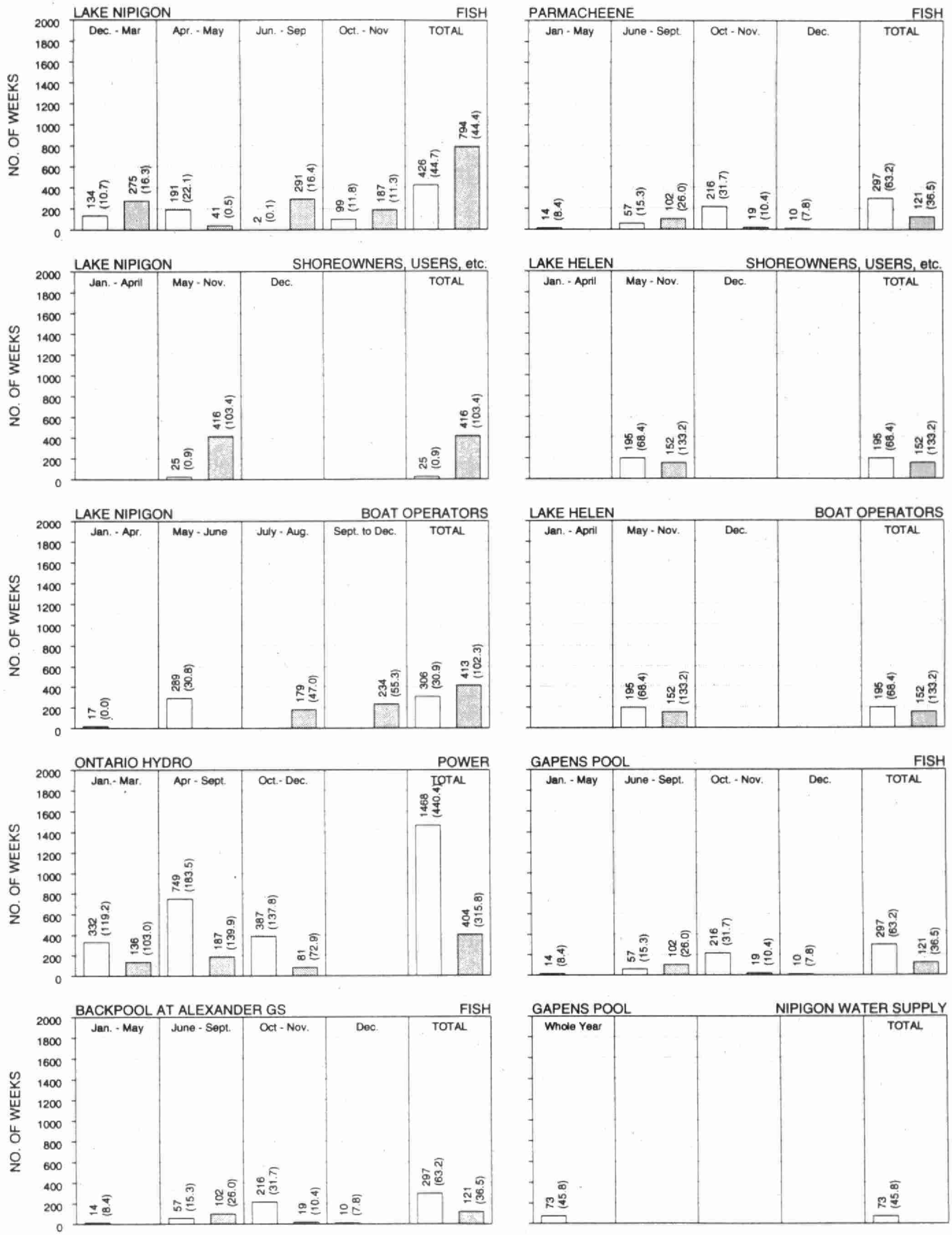


OPT5.SIM

CASE:-60% L.Fish, 25% R.Fish, 10% Hydro, 2.5% L.Shore, 2.5% L. Helen

TOTAL 1872 WEEKS

- ☐ AVERAGE LEVEL OR FLOW BELOW THE EXPECTED RANGE
- ▩ AVERAGE LEVEL OR FLOW ABOVE THE EXPECTED RANGE



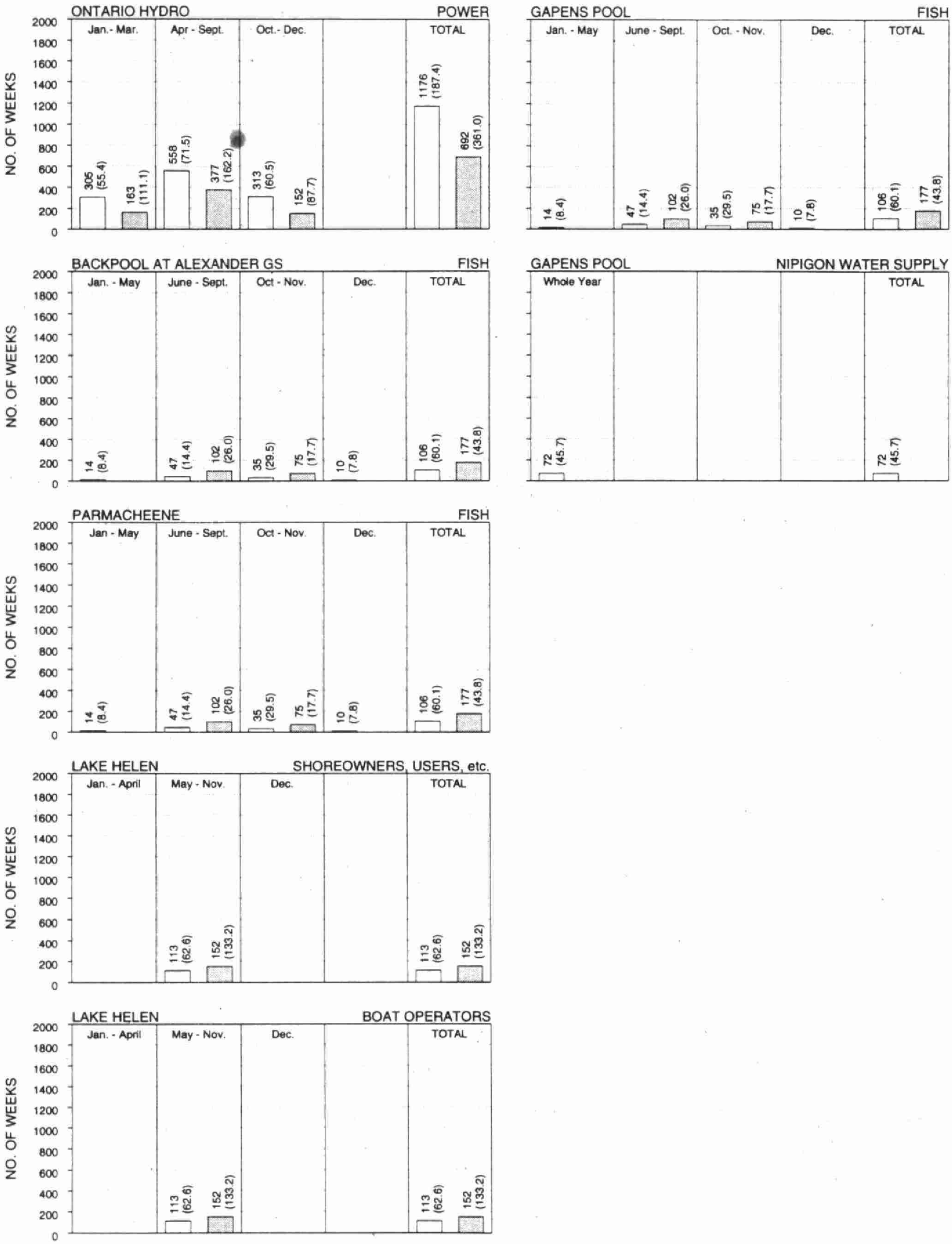
OPT5.SIM

CASE:-60% L.Fish, 25% R.Fish, 10% Hydro, 2.5% L.Shore, 2.5% L. Helen

☐ MAXIMUM FLOW BELOW THE EXPECTED RANGE

▨ MAXIMUM FLOW ABOVE THE EXPECTED RANGE

TOTAL 1872 WEEKS



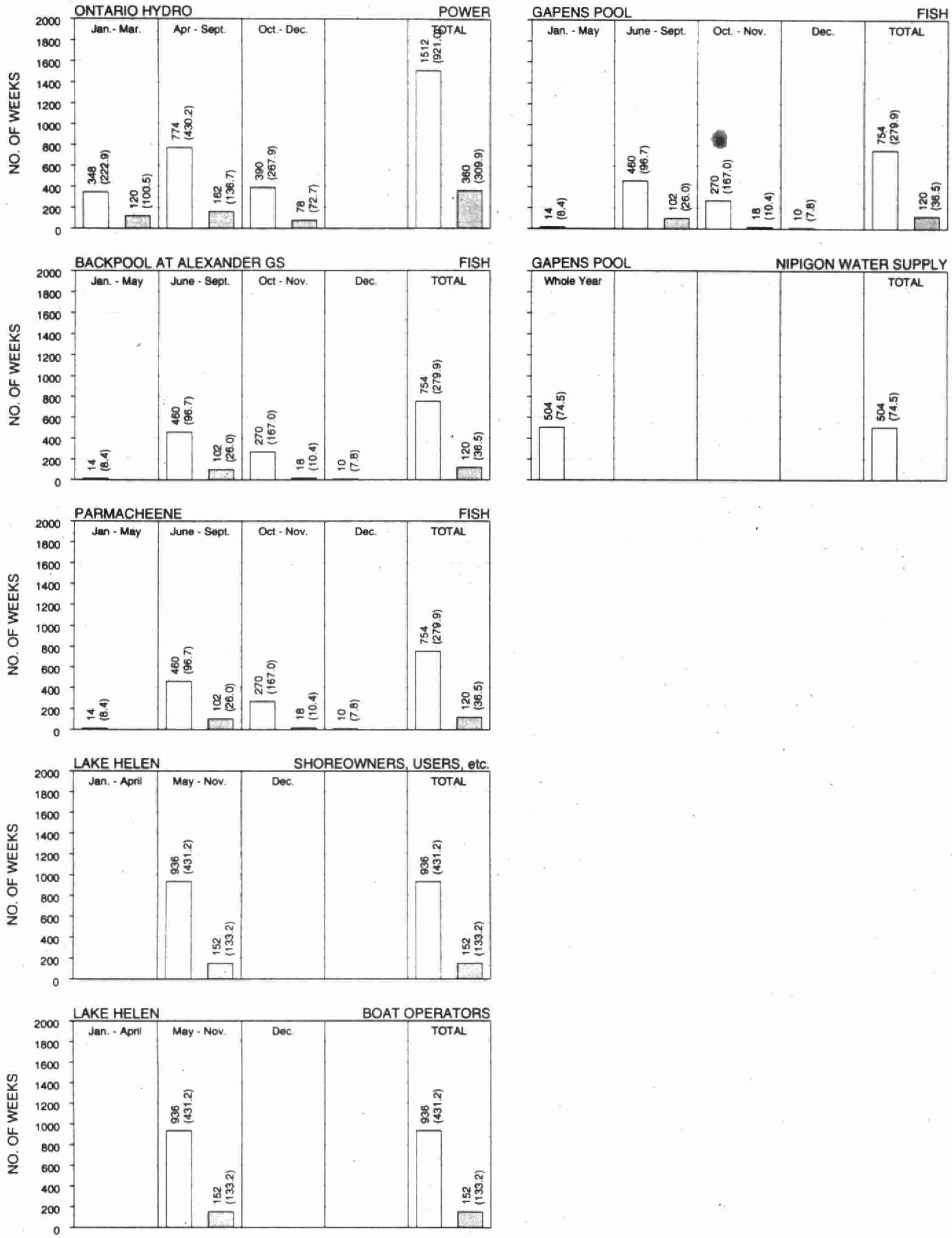
OPT5.SIM

CASE:-60% L.Fish, 25% R.Fish, 10% Hydro, 2.5% L.Shore, 2.5% L. Helen

TOTAL 1872 WEEKS

MINIMUM FLOW BELOW THE EXPECTED RANGE

MINIMUM FLOW ABOVE THE EXPECTED RANGE



OPT5.SIM
CASE:-60% L.Fish, 25% R.Fish, 10% Hydro, 2.5% L.Shore, 2.5% L. Helen

INCREMENTAL CHANGE

FROM:	0	42	260.07	TO:	1	15	259.43	0.64
FROM:	1	39	259.76	TO:	2	16	259.27	0.49
FROM:	2	39	260.08	TO:	3	15	259.45	0.63
FROM:	3	39	260.08	TO:	4	15	259.46	0.62
FROM:	4	41	259.98	TO:	5	17	259.38	0.60
FROM:	5	39	259.95	TO:	6	15	259.40	0.55
FROM:	6	39	260.06	TO:	7	14	259.44	0.62
FROM:	7	43	260.15	TO:	8	17	259.39	0.76
FROM:	8	39	260.10	TO:	9	14	259.45	0.65
FROM:	9	39	259.74	TO:	10	14	259.31	0.43
FROM:	10	40	260.03	TO:	11	16	259.37	0.66
FROM:	11	39	260.00	TO:	12	16	259.31	0.69
FROM:	12	39	260.08	TO:	13	15	259.41	0.67
FROM:	13	40	260.37	TO:	14	16	259.41	0.96
FROM:	14	41	259.86	TO:	15	15	259.48	0.38
FROM:	15	39	260.03	TO:	16	14	259.37	0.66
FROM:	16	39	259.87	TO:	17	14	259.34	0.53
FROM:	17	46	260.22	TO:	18	15	259.47	0.75
FROM:	18	40	260.22	TO:	19	16	259.40	0.82
FROM:	19	44	260.44	TO:	20	14	259.58	0.86
FROM:	20	46	260.25	TO:	21	16	259.44	0.81
FROM:	21	39	259.75	TO:	22	14	259.29	0.46
FROM:	22	44	259.86	TO:	23	16	259.37	0.49
FROM:	23	45	260.18	TO:	24	17	259.37	0.81
FROM:	24	39	259.90	TO:	25	14	259.29	0.61
FROM:	25	39	259.64	TO:	26	14	259.24	0.40
FROM:	26	44	260.16	TO:	27	17	259.36	0.80
FROM:	27	39	260.08	TO:	28	15	259.34	0.74
FROM:	28	39	259.80	TO:	29	16	259.31	0.49
FROM:	29	42	259.72	TO:	30	14	259.30	0.42
FROM:	30	39	259.53	TO:	31	17	259.11	0.42
FROM:	31	44	259.84	TO:	32	17	259.43	0.41
FROM:	32	40	259.77	TO:	33	14	259.30	0.47
FROM:	33	39	259.92	TO:	34	15	259.33	0.59
FROM:	34	40	260.33	TO:	35	16	259.43	0.90

ANNUAL DRAWDOWN (M):
AVERAGE = 0.62
ST.DEV. = 0.16
MAXIMUM = 0.96
MINIMUM = 0.38

MAXIMUM ELEVATION IN FALL (M):
AVERAGE = 259.99
ST.DEV. = 0.21
MAXIMUM = 260.44
MINIMUM = 259.53

MINIMUM ELEVATION IN SPRING (M):
AVERAGE = 259.37
ST.DEV. = 0.08
MAXIMUM = 259.58
MINIMUM = 259.11

MINIMUM OFF PEAK FLOWS
FOR WEEK 23-39 Q= 170.00
THE REST Q= 270.00

		NO. OF WEEKS
NO PEAKING	=	421
PEAKING	=	1451
QON-QOFF > 100 CMS	=	1174
QON-QOFF > 200 CMS	=	334
QON-QOFF > 300 CMS	=	0

**** FOR POWER CALCULATION ****

MINIMUM OFF PEAK FLOWS

FOR WEEK 23-39	Q=	170.00
THE REST	Q=	270.00

		MWh	DOLLARS
ON PEAK	=	51076700.	929339900.
OFF PEAK	=	13181360.	163813400.

ANNUAL AVERAGE

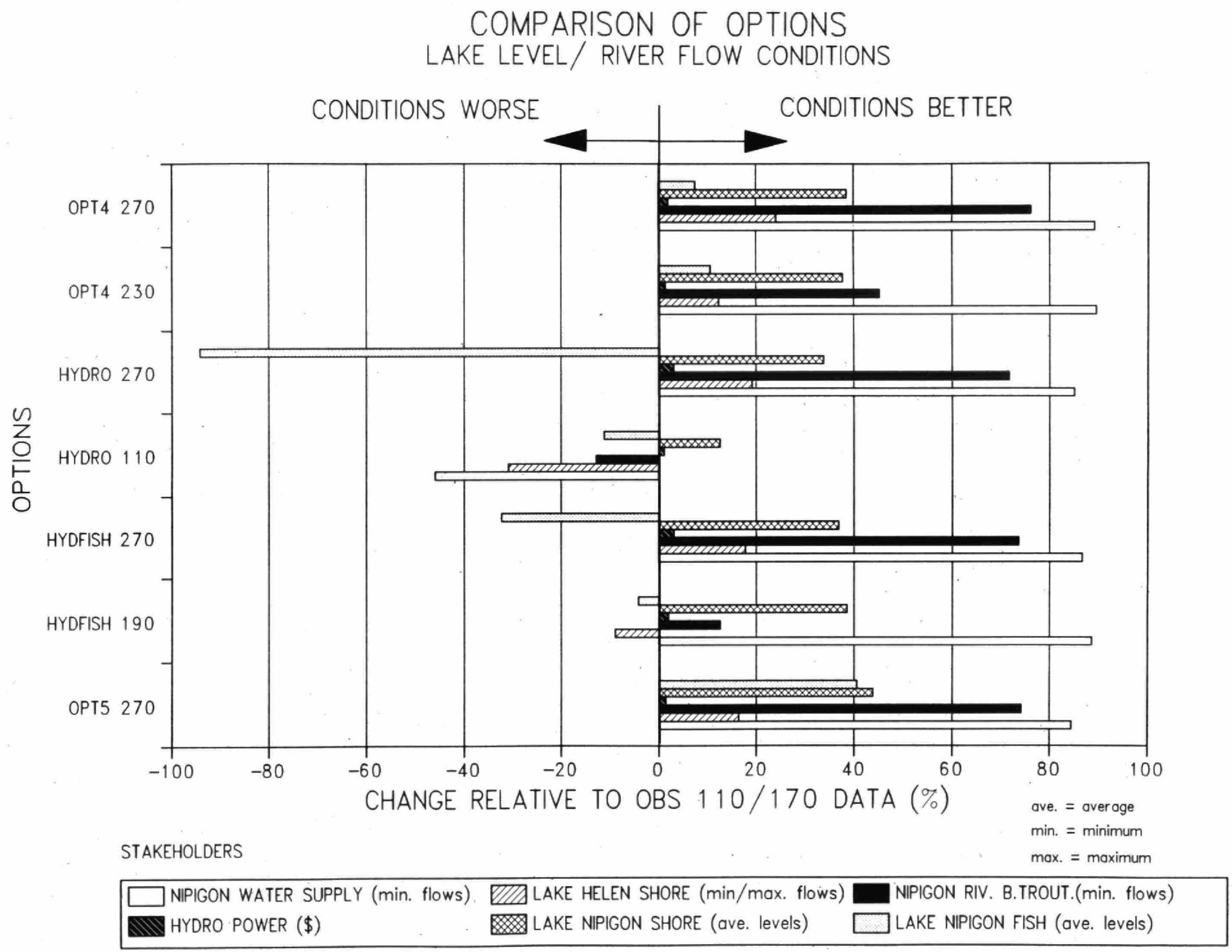
		MWh	DOLLARS
ON PEAK	=	1418797.	25815000.
OFF PEAK	=	366149.	4550374.
		1977	1981-82
ON PEAK	=	7057122.	9094995.
OFF PEAK	=	3796706.	6000066.

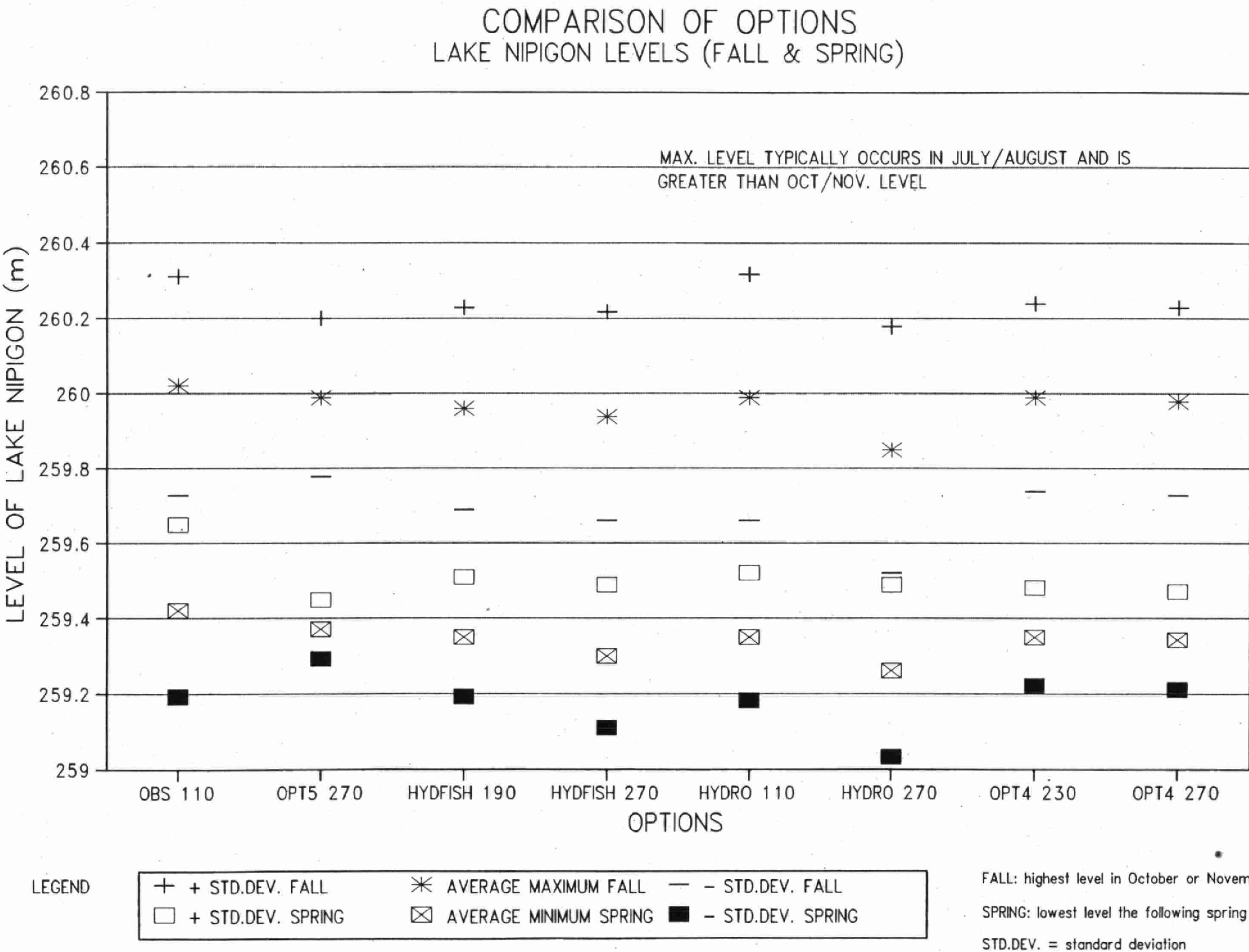
ANNUAL POWER

YEAR	ON PEAK MWH	OFF PEAK MWH	TOTAL MWH	ON PEAK $	OFF PEAK $	TOTAL $
1951	1748574.	193247.	1941820.	32187940.	2059549.	34247490.
1952	1358963.	374385.	1733347.	25256520.	4468560.	29725080.
1953	1297454.	430544.	1727998.	23187990.	5522219.	28710200.
1954	1789736.	219119.	2008855.	32432550.	2855869.	35288420.
1955	1457364.	382540.	1839904.	26680210.	4693762.	31373970.
1956	1425007.	417746.	1842753.	25906360.	5251967.	31158320.
1957	1469260.	403862.	1873121.	26420310.	5224669.	31644980.
1958	1476517.	368780.	1845296.	26838560.	4549065.	31387620.
1959	1485711.	380780.	1866491.	27309960.	4560272.	31870230.
1960	1188917.	446861.	1635778.	21674890.	5601606.	27276490.
1961	1352551.	414211.	1766761.	24260860.	5271010.	29531870.
1962	1372356.	425680.	1798036.	24978010.	5372201.	30350210.
1963	1364930.	411330.	1776260.	24908540.	5179410.	30087950.
1964	1849982.	186934.	2036916.	33142070.	2627536.	35769610.
1965	1539399.	317294.	1856693.	28634470.	3572220.	32206690.
1966	1618920.	335961.	1954880.	29227710.	4413778.	33641490.
1967	1375947.	425680.	1801627.	25019770.	5372201.	30391970.
1968	1654120.	281211.	1935332.	29547400.	3694319.	33241710.
1969	1890027.	173791.	2063818.	34751480.	1791236.	36542720.
1970	1718679.	266275.	1984954.	31197390.	3256046.	34453430.
1971	1804604.	165995.	1970599.	33084530.	1778255.	34862780.
1972	1470614.	290939.	1761553.	27397310.	3235249.	30632550.
1973	1294916.	425680.	1720597.	23339100.	5372201.	28711300.
1974	1541220.	354585.	1895806.	27725280.	4489238.	32214510.
1975	1502732.	332541.	1835273.	27864850.	3836334.	31701190.
1976	856156.	464868.	1321025.	15567250.	5863649.	21430900.
1977	1272760.	428199.	1700958.	22275390.	5599467.	27874860.
1978	1390655.	435640.	1826295.	25364380.	5472007.	30836380.
1979	1337657.	425680.	1763337.	24305390.	5372201.	29677600.
1980	927011.	523373.	1450384.	17149080.	6510469.	23659540.
1981	712170.	444515.	1156686.	12843060.	5678613.	18521670.
1982	896723.	487946.	1384669.	15966290.	6206558.	22172840.
1983	1286987.	423714.	1710702.	23611210.	5327232.	28938440.
1984	1339853.	425680.	1765533.	24255640.	5372201.	29627840.
1985	1523749.	356158.	1879907.	27656470.	4335636.	31992110.
1986	1484149.	339578.	1823727.	27373300.	4026280.	31399580.

Appendix G

- Comparison of Different Minimum Flow Restrictions


COMPARISON OF OPTIONS
LAKE LEVEL/ RIVER FLOW CONDITIONS
CONDITIONS WORSE
CONDITIONS BETTER
OPTIONS
OPT4 270
OPT4 230
HYDRO 270
HYDRO 110
HYDFISH 270
HYDFISH 190
OPT5 270
-100
-80
-60
-40
-20
0
20
40
60
80
100
CHANGE RELATIVE TO OBS 110/170 DATA (%)
ave. = average
min. = minimum
max. = maximum
STAKEHOLDERS
NIPIGON WATER SUPPLY (min. flows)
LAKE HELEN SHORE (min/max. flows)
NIPIGON RIV. B.TROUT.(min. flows)
HYDRO POWER ($)
LAKE NIPIGON SHORE (ave. levels)
LAKE NIPIGON FISH (ave. levels)



FALL: highest level in October or November

SPRING: lowest level the following spring

STD.DEV. = standard deviation

Remedial Action Plan
Plan d'Assainissement

Canada Ontario

Canada-Ontario Agreement Respecting Great Lakes Water Quality
L'Accord Canada-Ontario relatif à la qualité de l'eau dans les Grand Lacs